Andhra Pradesh Gas Market Study

Final Report (May 2001)

Prepared for **BP International Ltd.**

TERI Project Report No. 2000 OG 42

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ıdesh - A brief profile

.he instance of BP to estimate short-term
ɑ demand (by 2015) for gas in the state of
ference of the study are attached as Appendix 1.
ɟer study is given below.

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ıataka, on the north by the states of
nd Orissa and on the east by the Bay of Bengal.
ıe state is at Figure 1.1.
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The stress is on building up the services sector,
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:hange radically as shown below.

Figure 1.1 The state of Andhra Pradesh

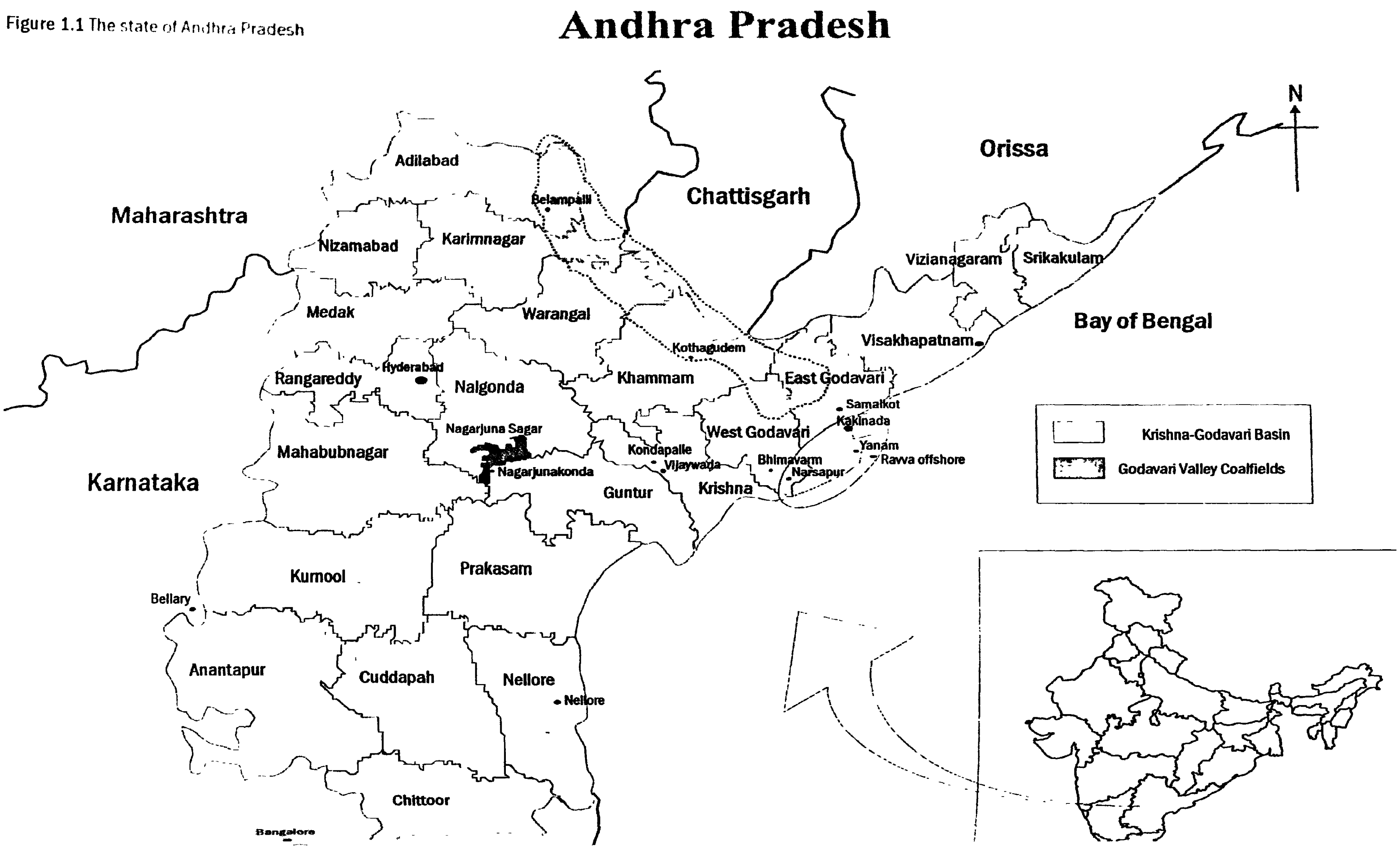
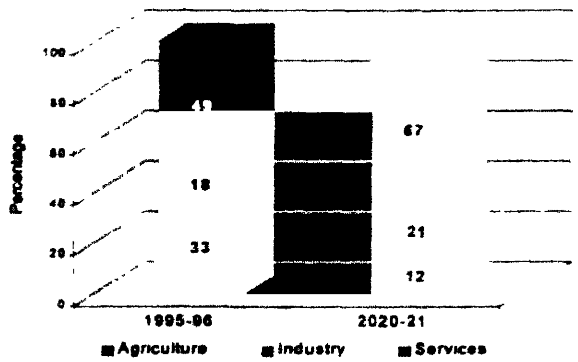


Figure 1.2 Andhra Pradesh: sectoral contributions to GDP



Source. AP Vision 2020

Andhra Pradesh currently has a population of about 76 million with the compound annual growth rate during 1995-2000 registering 1.3%. However, the State Government proposes to reduce the growth rate to 1% by 2005 and to 0.5% by 2020.

The urban and rural literacy rates have been on the rise since 1981 and the state government aims at full literacy by 2010.

Andhra Pradesh is a storehouse of key minerals such as coal, iron ore, limestone, granite, bauxite and barytes. In fact, the state is estimated to have a third of India's total mineral wealth. It has 20% of India's limestone reserves and 27% of its bauxite reserves. It is the largest producer of barytes in India and the second largest in the world. The world's best granite, Black Galaxy, is found in Andhra Pradesh.

The energy sector

Coal reserves

Andhra Pradesh is the sole producer of coal in south India. Coal occurs in Gondwana formations of Godavari valley. The coal from these fields have a high moisture and ash content, are high in volatiles and are of the non-coking type. They are mainly suitable for power generation. The Godavari Valley Coalfields are operated by the Singareni Collieries Co. Ltd. (SCCL) - a joint undertaking of the Government of Andhra Pradesh and the Government of India, with its headquarters at Kothagudem.

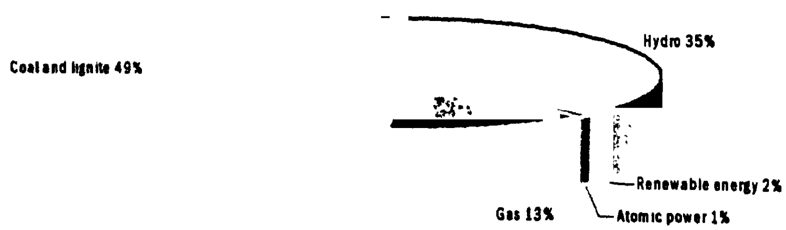
About 95% of the coal produced by SCCL is consumed in Andhra Pradesh. Coal is also supplied to Andhra Pradesh by Mahanadi Coalfields Ltd. (Talcher

coalfields in Orissa) and Western Coalfields Ltd. (Umrer coalfields in Nagpur, Maharashtra), both subsidiaries of the Coal India Limited.

The power sector

Andhra Pradesh has a total installed capacity of 7856.62 MW as on October 31, 2000. Of this, the Andhra Pradesh Power Generation Corporation (APGENCO) accounts for nearly 70%. The share of the joint and central sector stands at 17% and the remaining 13% is in the private sector. The shares of coal and lignite, hydro, renewables and gas, in installed capacity have been shown in Figure below.

Figure 1.3 Fuelwise installed power generation capacity in Andhra Pradesh (31, October 2000)



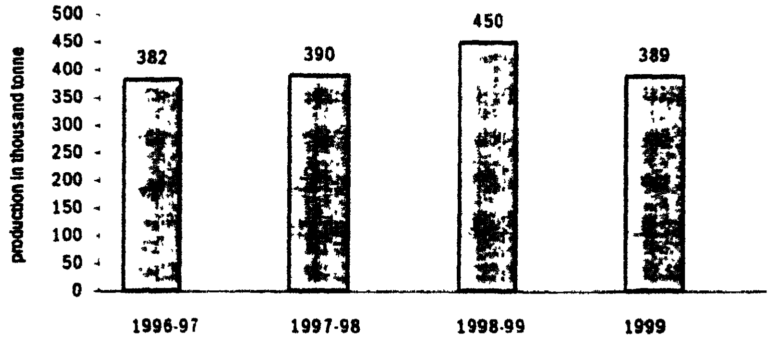
Source. APGENCO

Oil and gas reserves

Oil and gas are produced in the state in the Krishna-Godavari (K-G) basin. Gas has been produced and used in the state since 1988-89. The Oil and Natural Gas Corporation Limited (ONGC) is the major producer of oil and gas from this basin. It operates 32 onshore and 7 offshore oil and gas wells in the area (as of April 1999). The major gas producing off-shore field is Ravva, off the coast of East Godavari district operated by Cairn Energy. Some of the other important gas production sites are Endamaru, Suryasaya Yanam, Tatipaka, Kessna Palli and Mori.

ONGC recorded a crude oil output of 140,000 tons in 1999-00 (March-April), higher than the target of 80,000 tons.

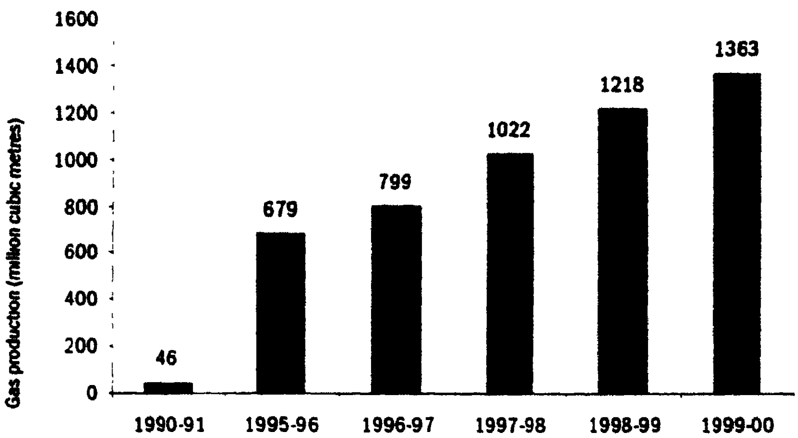
Figure 1.4 Crude oil production in Andhra Pradesn



Source. Ministry of Petroleum and Natural Gas

On-shore gas production in Andhra Pradesh is shown in Figure 1.5 below.

Figure 1.5 On-shore gas production in Andhra Pradesh



Source. Ministry of Petroleum and Natural Gas

Gas production from the Ravva field has been around 0.7 MMCMD since 1998. Oil and gas production is projected to increase in the K-G basin with 4 offshore blocks (approx. area of 15,755 sq kms) and 5 deep-water blocks (approx. area of 47,175 sq kms) being offered under the New Exploration Licensing Policy.

Gas use in Andhra Pradesh

At present, around 5.7 MMCMD of gas is being consumed in Andhra Pradesh. This gas is being supplied from the onshore Krishna-Godavari fields of ONGC

and the offshore Ravva field operated by Cairns. The gas from all sources is marketed by the Gas Authority of India Limited (GAIL).

The Government of India allocates gas to all consumers. In the case of Andhra Pradesh, an allocation of 14.36 MMCMD has been made to various sectors although the projected peak availability is only 9 MMCMD. This over-allocation reflects the widely held view that further exploration will make new reserves and hence more gas available in the state.

The allocations of gas to power, fertiliser and other sectors of Andhra Pradesh have been shown in Table 1.1.

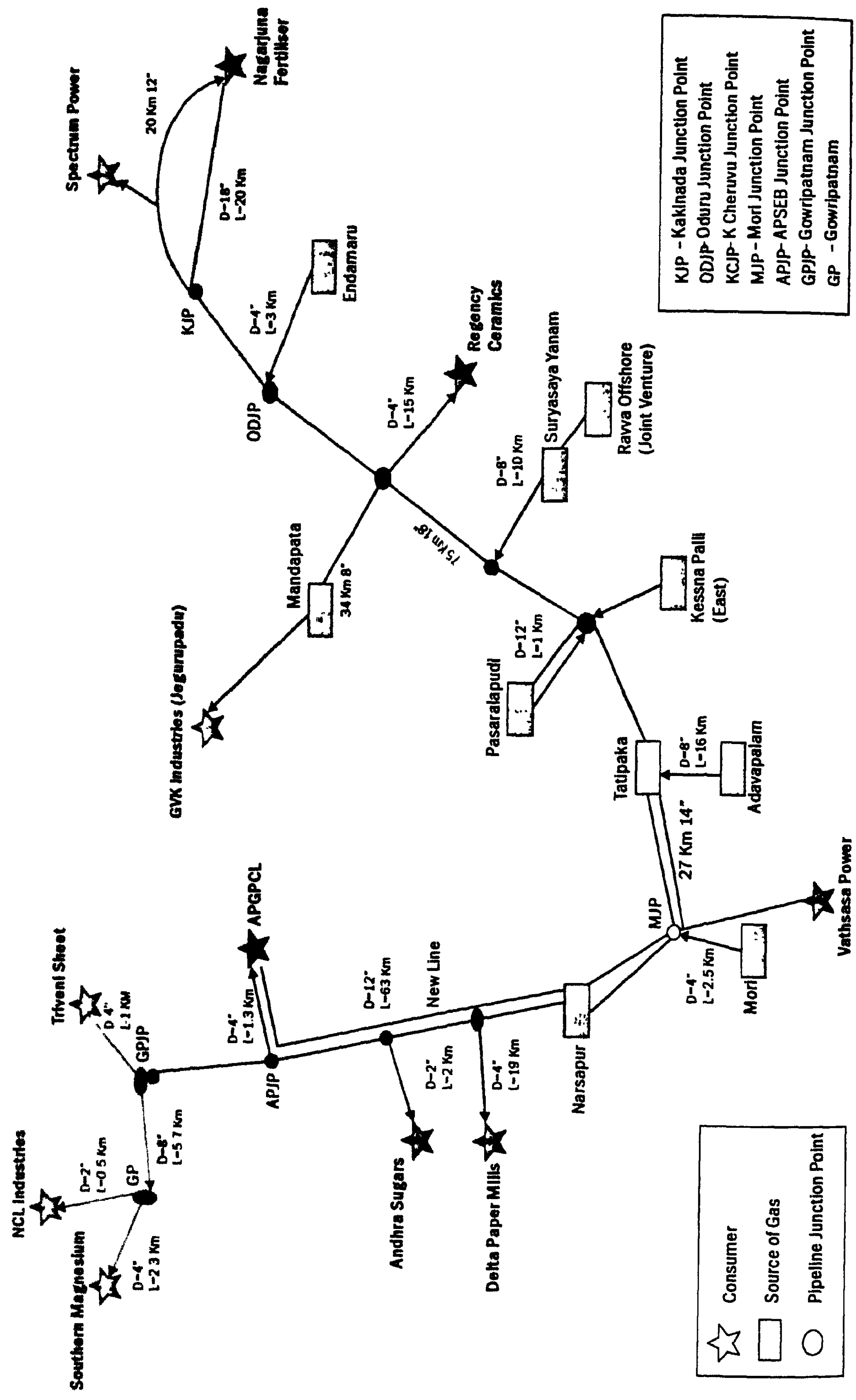
Table 1.1 Gas allocations in Andhra Pradesh

Customer	*Allocation*
Power	
Andhra Pradesh Gas Power Corpn. Ltd.	1.32
GVK Industries	1.85
Spectrum Power Generation Ltd.	1.5
Konaseema Power	1.6
Vathsasa Power	0.065
LANCO Kondapalli	1.12
Gautami Power Limited	1.22
NCC Power	0.74
Vemagiri Power	1.64
Sub Total	11.055
Fertiliser	
Nagarjuna Fertilizer and Chemicals Ltd.	2.75
Sub Total	2.75
Industry	
Delta Paper	0.055
Andhra Sugars	0.01
Southern Magnesium and Chemicals Ltd.	0.01
NCL Industries Ltd.	0.004
Regency Ceramics	0.145
Vennar Ceramics	0.04
Andhra Fuels	0.1
Global Steels	0.0035
Sri Rama Ceramics	0.003
Triveni Sheet	0.04
Dasika Industrial Chem	0.005
Sree Akkamma Textiles	0.012
Regent Agro Product	0.01
Swaroop	0.012
Rolex Paper Mills Ltd	0.008
Sub Total	0.4575
City Distribution	
Andhra Pradesh Industrial Infrastructure Corpn. Ltd.	0.1
Sub Total	0.1
Total	*14.3625*

Source. GAIL

In keeping with these allocations, GAIL has huge investment plans to expand its supply network including construction of a 190 km long pipeline from Narsapur junction to LANCO power station at Kondapalli. The existing gas pipeline grid of GAIL in K-G Basin has been shown in Figure 1.6.

Figure 1.6 GAIL gas pipeline network in the K-G basin

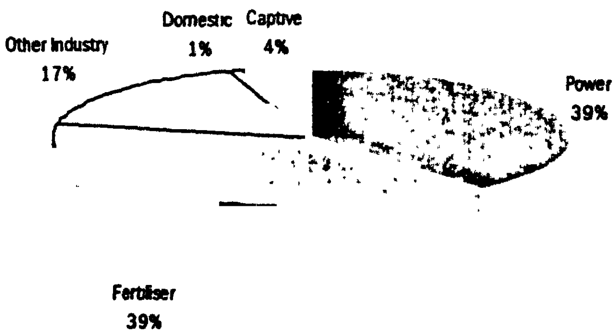


2 Estimation of gas demand

Introduction

The pattern of gas use in India has not been market driven. It has been based on allocations by the Government and has reflected the priorities of the Government. About 80% of the gas is consumed today by the power and fertiliser sectors as shown in Figure 2.1 below.

Figure 2.1 Gas consumption pattern in India: 1998-99



Source. Ministry of Petroleum and Natural Gas

A change over to a market driven system, however, will not significantly alter the sectoral gas use. Future gas use pattern in India and in Andhra Pradesh is likely to be similar to the present pattern of gas use. The power and fertiliser units will continue to be the anchor customers. Industrial demand will be low on account of preponderance of small scale units and also because of the availability of cheap coal. However, energy intensive industries in the neighbourhood of anchor customers or along gas pipelines are expected to change over to gas. Gas use for domestic purposes will continue to be low as space heating is not required and the gas is used only for cooking. Once again, urban clusters along the pipeline routes could provide some demand for gas.

In estimating the gas demand, we have therefore looked separately at the following sectors:

- power
- fertiliser

- captive power generation
- industries
- domestic and commercial

In all these sectors, we start with the current demand. To this we add the additional demand from expansion plans as determined through a survey or through available information. This gives us the short-term gas demand upto 2005. Beyond this, the demand estimates are based on projections of growth in the respective sectors and competition from alternative fuels. The basis for such projections are different for each sector. These are explained in the concerned sections of this report. The imputed values of gas use in these sectors as developed in Chapter 4, help us in getting to the price profile of the demand projections.

Gas demand in the power sector

Existing gas demand

The existing gas demand in the power sector in Andhra Pradesh is about 4.8 MMCMD.

Table 2.1 Existing gas demand in power sector

Power Units	Gas demand (MMCMD)
Andhra Pradesh Gas Power Corpn. Ltd.	1.32
GVK Industries	0.90
Spectrum Power Generation Ltd.	0.83
LANCO Kondapalli	1.75
Total	4.80

Source. GAIL

The first three units above are currently drawing gas. LANCO Kondapalli power unit is now running on naphtha and is expecting gas supplies from December 2001.

Potential gas demand

The short-term demand projections upto 2005

The existing installed capacity and likely capacity additions by 2005 are shown below.

Table 2.2 Installed capacity (MW) in Andhra Pradesh (as on October 31, 2000)

				Joint and Central		Private	
Station (Thermal)	Capacity	Station (Hydro)	Capacity	Station	Capacity/Share	Station/Fuel type	Capacity
Rayalseema	420	Upper Sileru I	240	Vijjeswaram	272	Jegurupadu	216
Kothagudem	1180	Lower Sileru	460	Ramagundam	580	Kakinada	207.88
Vijayawada	1260	Donkarayi	25	MAPS	28	Kondapalli	360
RamagundamB	62.5	Srisailam	770	NLC-I	97	Wind	84.99
Nellore	30	Nagarjun-asagar	810	NLC-II	180	RCL	41
		NS RCPH	90	Kaiga	57.5	Biomass	2.75
		NS LCPH	60	Machkund	80	Bagasse	19.3
		Nizamsagar	10	TB Dam	58	Biomass PP	1
		Pochampad	27			Mini plants	40
		P.Ahobilam	20			Mini Hydro	42.7
		KCPH	4				
		Chettipet	1				
		Paleru	2				
		Singur	15				
Total APGENCO [a]	5488.5			Total Joint & Central	1352.5	Total Private	1015.6
Total Capacity	7856.62						

Source. APGENCO

Table 2.3 Likely capacity additions in Andhra Pradesh (2000-2005)

Location	Promoter	Fuel Type	Capacity (MW)	Date Comm.
Under construction				
Srisailam LBPH	APGENCO	Hydro	900	2000-03
Peddapuram Samalkot	BSES	Naphtha	200	2001
LVS Power Project	LVS Power Ltd.	LSHS	36.8	2001
Simhadri	NTPC	Coal	1000	2002
Ramagundam-III	NTPC	Coal	234	2003
Talcher-II	NTPC	Coal	425	2004-06
Planned				
Jeggurupadu (expansion)	GVK	Gas	220	2004
Peddapuram	Gautami Power & NCC	Gas	477	2004
Vemagiri	Vemagiri	Gas	520	2004
Konaseema	Oakwell	Gas	360	2005
Ramagundam	BPL Power Projects	Coal	520	2005
Total likely capacity addition 4892.8				

Source. Own estimates

The information in the Table above has been compiled after interviews with the concerned promoters, APGENCO and APTRANSCO officials. There is still some uncertainty over the dates of commissioning of these units. If these units come up as per the above schedule, a total of 1777 MW of gas based power will be added by 2005.

The potential gas demand till 2006 as gathered from GAIL adds up to 15.76 MMCMD as shown in Table 2.4 below.

[a] Includes 2 MW of wind based installed capacity.

Table 2.4 Gas demand for power generation till 2006

Category	Gas demand (MMCMD)	Units considered
Existing	4.8	APGPCL, GVK, Spectrum and LANCO
Additional		
2001	1.06	BSES
2004	6.8	GVK (expansion), Gautami and NCC, Vemagiri
2005	1.6	Konaseema
2006	1.5	Spectrum (expansion)
Total	15.76	

The long-term demand projections upto 2015

Power demand projections. The trend in sectoral power consumption in the 1990's can be seen in Table 2.5.

Table 2.5 Energy Sales (MkWh) and T&D Losses (MkWh) in Andhra Pradesh (1992-99)

Year	Domestic	Commercial	Agri/ Irrigation	Industrial	Railway traction	Outside state	Others	Total Sales	T&D losses	Energy Avail-ability	T&D losses (%)
1992	2825	610	7936	6716	461	142	696	19386	4681	24067	19.2
1993	3187	673	9022	6899	552	122	891	21346	5117	26463	19.1
1994	3320	683	11270	7549	595	54	222	23692	5486	29178	18.9
1995	3393	715	11757	6885	631	25	311	23718	5575	29293	18.9
1996	3922	805	8210	6804	687	88	895	21412	10589	32001	33.1
1997	5426	927	9372	6849	850	146	374	23944	11863	35807	32.5
1998	6181	1087	9547	7107	905	152	451	25430	12375	37805	31.9
1999	6958	1200	10050	7734	1150	155	491	27738	13167	40905	31.1

Source Annual Report on the Working of State Electricity Boards and Electricity Departments. Planning Commission, Government of India. April 2000

Projections of power demand usually rely on this sectoral consumption numbers. However, we have not relied on these as:

- energy sales reported for the state represent restricted energy requirement
- non-metering of sales to the agricultural sector results in misclassification of energy use
- T&D losses, although they have risen sharply from 19% in 1995 to 33% in 1996 in Andhra Pradesh, may still be underestimated.

The total energy requirement in the state, as reported by the Central Electricity Authority (CEA), provides an alternative basis for making these projections. These are shown in the Table below.

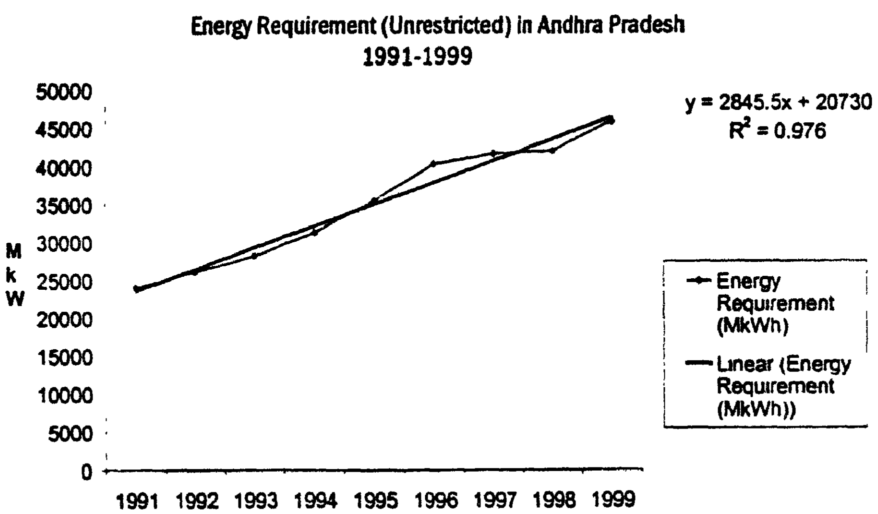
Table 2.6 Power supply position in Andhra Pradesh (1991-99)

Year	Peak Requirement (MW)	Peak Availability (MW)	Peak Surplus (+) Deficit(-)	Peak Surplus (+) Deficit(-) (%)	Energy Requirement (MkWh)	Energy Availability (MkWh)	Energy Surplus (+) Deficit(-)	Energy Surplus (+) Deficit(-) (%)
1991	4160	3504	-656	-15.8	24015	22415	-1600	-6.7
1992	4690	3693	-997	-21.3	26085	24281	-1804	-6.9
1993	4800	3836	-964	-20.1	28180	26924	-1256	-4.5
1994	5100	4177	-923	-18.1	31245	28757	-2488	-8.0
1995	5504	4355	-1149	-20.8	35458	30029	-5429	-15.3
1996	5940	4540	-1400	-23.6	40240	31359	-8881	-22.1
1997	6111	5423	-688	-11.3	41599	35606	-5993	-14.4
1998	6770	6139	-631	-9.3	41958	38293	-3665	-8.7
1999	7209	6366	-843	-11.7	45835	42832	-3003	-6.6

Note Figures for the year 1995-96 have been interpolated.
Source. CEA

A linear trend was fitted to the energy requirements over the years 1991-99 as shown below.

Figure 2.2 Trend in energy requirement in Andhra Pradesh (1991-1999)



This has been used to forecast energy requirement till 2015. From 1991 to 1996, the load factor increased from 66% to 77% but there after declined to 72.6% in 1999. It has been assumed that the decreasing trend would continue and the load factor would decline to 67% in 2015 on account of measures taken to flatten the demand curve.

The energy requirement and the peak demand upto 2015 are projected as below:

Table 2.7 Power demand forecasts for Andhra Pradesh (2000-2015)

Year	*Energy requirement (MkWh)*	*Peak demand (MW)*
2000	49185	7773
2001	52031	8263
2002	54876	8757
2003	57722	9256
2004	60567	9761
2005	63413	10270
2006	66258	10784
2007	69104	11303
2008	71949	11828
2009	74795	12358
2010	77640	12893
2011	80486	13433
2012	83331	13980
2013	86177	14532
2014	89022	15089
2015	91868	15652

The official projections of power demand are made in the Electric Power Surveys (EPS) by the CEA periodically. The 15th EPS was published in 1997. The 16th EPS released this year has revised the earlier projections upward. Our estimates of energy requirement and peak demand in Andhra Pradesh are intermediate between the estimates made in the 15th EPS and the 16th EPS for the years 2006/7, 2011/12 and 2016/17.

Figure 2.3 Companson of forecasts of Energy Requirement (MkWh)

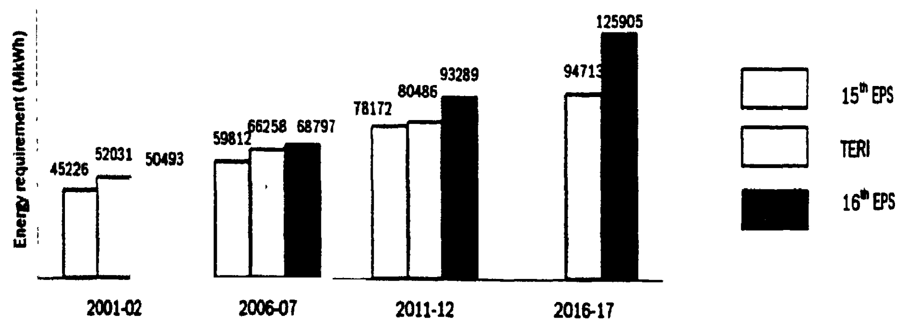
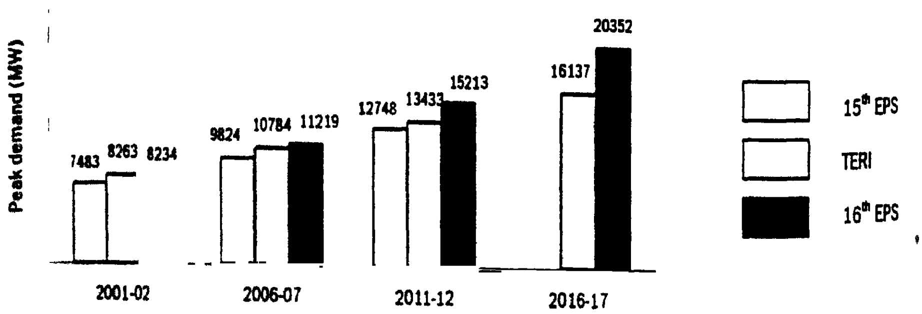


Figure 2.4 Companson of forecasts of Peak Demand (MW)



The reserve margin

In drawing up power capacity plans based on the demands projected in the EPSs, the CEA usually takes a reserve margin of 30%. This reserve margin meets the required reliability criteria such as a Loss of Load Probability (LOLP) of 1%. Discussions with the CEA suggest that the reserve margin should be in the range of 25%-30%, in no case below 25%. However it is to be noted that LOLP at present is 3-5% and the reserve margin is 10-15%. In projecting the additional capacity requirement, we have therefore taken the two margins of 15% and 30%.

Likely Capacity Surplus/Deficit from 2005 to 2015

Based on the above analysis, the demand-supply position of power is projected to 2015 as below.

Table 2.8 Power demand and likely capacity surplus/deficit for Andhra Pradesh (2005-2015)

Year	*Energy requirement (MkWh)*	*Peak demand (MW)*	*Peak capacity reqd. (MW) (15% Margin)*	*Peak capacity reqd. (MW) (30% Margin)*	*Likely Capacity(MW)*	*Capacity surplus (+) /deficit (-) (MW) (15% Margin)*	*Capacity surplus (+) /deficit (-) (MW) (30% Margin)*
2005-06	63413	10270	11810	13351	12749	939	-601
2006-07	66258	10784	12401	14019	13529	1128	-490
2007-08	69104	11303	12999	14694	14709	1711	15
2008-09	71949	11828	13602	15376	14819	1217	-557
2009-10	74795	12358	14211	16065	15404	1193	-660
2010-11	77640	12893	14827	16761	15404	578	-1356
2011-12	80486	13433	15449	17464	15404	-44	-2059
2012-13	83331	13980	16077	18174	15404	-672	-2769
2013-14	86177	14532	16711	18891	15404	-1307	-3487
2014-15	89022	15089	17352	19616	15404	-1948	-4211
2015-16	91868	15652	18000	20348	15404	-2596	-4944

The likely capacity additions considered in the above table are based on the following:

Table 2.9 Likely capacity additions in Andhra Pradesh (2006-2015)

Location	*Promoter*	*Fuel Type*	*Capacity (MW)*	*Date Comm.*
Rayalsema - II	APGENCO	Coal	420	2006
Kakinada (expansion)	SPGL	Gas	360	2006
VTPS	APGENCO	Coal	660	2007
Krishnapatnam -A	GVK Industries	Coal (IMP)	520	2007
Jaurala	APGENCO	Hydro	110	2008
Vishakhapatnam	HPCL	Ref. Res.	585	2009
Vishakhapatnam	HNPCL	Coal	1040	Delayed
Krishnapatnam	M/S BBI Power	Coal (IMP)	520	Delayed
Total likely capacity addition 2655				

Source. Own estimates.

Note. Delayed projects have not been included in the total likely capacity additions.

A more reasonable picture emerges if we assume a 15% reserve margin in 2005 which gradually builds up to 30% by 2015. It is further assumed that the likely capacity in the initial years will be restricted to the required capacity. The power demand-supply in such a case is presented in Table 2.10 below.

Table 2.10 Power demand and likely capacity surplus/deficit with varying reserve margin

Year	Energy requirement (MkWh)	Peak demand (MW)	Peak Capacity required (MW)	Likely capacity (MW)	Capacity gap (MW)
2005-06	63413	10270	11810	11810	0
2006-07	66258	10784	12720	12720	0
2007-08	69104	11303	13630	13630	0
2008-09	71949	11828	14540	14540	0
2009-10	74975	12358	15450	15404	-46
2010-11	77640	12893	16360	15404	-956
2011-12	80486	13433	17270	15404	-1866
2012-13	83331	13980	18180	15404	-2776
2013-14	86177	14532	18892	15404	-3488
2014-15	89022	15089	19616	15404	-4212
2015-16	91868	15652	20348	15404	-4944

Meeting the deficit in 2015

If we go by the requirement of a 30% reserve (Table 2.8), and if all the planned power units are commissioned on schedule, a clear deficit in the power supply appears in the year 2008. On the other hand, if we allow the reserve margin to increase gradually (Table 2.10), this deficit appears by 2010. By 2015 this deficit reaches 4944 MW (based on a margin of 30%). This is proposed to be met through additional contribution from central public sector units (CPSUs) and a number of coal, hydel and other projects under investigation.

Table 2.11 Possible sources to meet power deficit in 2015

Source	Capacity (MW)
CPSUs	1000
Hydro	300
Mini Hydel/Wind/Biomass[2]	200
Coal	1088
Total	2588

The sources listed above account for an additional 2588 MW leaving a deficit of 2356 MW which could be met by new gas based units. The share from CPSUs includes additional share from Talcher, the southern grid (Cauveri hydro, Cheyur and Kayamkulam) and the western grid (Vindhyachal and Sipat) as considered by the CEA (Power on Demand by 2012). Hydro, mini hydel/wind/biomass and coal capacity additions are based on APGENCO projections (Power Development in Andhra Pradesh 1998-99). The addition of

hydropower would be limited as the large projects such as Inchampally, Pollavaram etc are tied to irrigation projects and require inter-state negotiations. APGENCO is studying the feasibility of new coal based plants all over the state. However, sites along the gas pipelines may not see coal based projects as gas is likely to be the preferred fuel.

Gas demand for power generation

Assuming that about 10 MMCMD of gas will be required to generate 2500 MW of power, the gas demand in 2015 to meet 2356 MW requirement is estimated at about 9 MMCMD. The potential gas demand till 2006 and the estimated gas demand in 2015 have been brought together in Table 2.12.

Table 2.12 Gas demand for power generation till 2015

Category	Gas demand (MMCMD)	Units considered
Existing	4 8	APGPCL, GVK, Spectrum and LANCO
Additional		
2001	1.06	BSES
2004	6.8	GVK (expansion), Gautami and NCC, Vemagiri
2005	1.6	Konaseema
2006	1.5	Spectrum (expansion)
2015	9.0	Estimated
Total demand	24.76	

Gas demand for urea production

Existing gas demand

The Nagarjuna Fertilizer and Chemicals Limited (NFCL) at Kakinada is the only existing fertilizer unit in Andhra Pradesh. It has a gas requirement of 2.75 MMCMD and an annual urea production capacity of 990 TMT.

Potential gas demand

The short-term demand projections upto 2005

In the short term, no additional gas demand is likely from this sector as NFCL does not have any expansion plans at present.

The long-term demand projections upto 2015

Urea demand projections for India

Fertiliser demand projections are based on projections of growth in agricultural production. The Fertilizer Association of India (FAI) estimates that the foodgrain production in India in 2012 will be 337.5 million tonnes. Two assumptions could be used to project fertiliser requirement to produce the additional foodgrain requirement:

1. 1 ton of fertilizer increases foodgrain production by 7.5 tonnes
2. 1 ton of fertilizer increases foodgrain production by 10 tonnes.

Out of the total consumption of fertilisers by all crops, 75 per cent is consumed by foodgrains currently. This ratio may decrease in future but in the absence of any reliable estimates the same ratio has been retained to evaluate total fertiliser requirement for 2012. As per Agricultural Statistics 2000 published by the Ministry of Agriculture, total fertiliser consumption in 1998-99 was 16.8 million tonnes. Consequently total fertiliser requirement in 2012 is estimated at 40.7 and 34.7 million tonnes with assumptions 1 and 2 respectively.

The total fertiliser requirement is converted to nitrogen requirement by using the N:P:K ratio of 5.9:2.4:1. This ratio was achieved in 1991-92 prior to the decontrol of phosphatic (P) and potassic (K) fertilizer prices. In subsequent years, the ratio was distorted by the change in relative prices.

In 1998-99, the use of urea by weight was 1.8 times the use of nitrogen. The same ratio has been assumed to hold upto 2012. With the above assumptions, the requirement of urea in 2012 works out as below.

Table 2.13 Requirement of urea in India (2012)

All India		*(Million tonnes)*	
	1998-99 (Actual)	2012 (Projected)	
Foodgrain requirement	203	337.3	
Additional foodgrains requirement		134.3	
		Assumption 1	Assumption 2
Additional fertiliser requirement for foodgrain		17.9	13.4
Additional fertiliser requirement for all crops		23.9	17.9
Present fertiliser requirement	16.8		
Total fertiliser requirement		40.7	34.7
Total nitrogen requirement		25.8	22.0
Requirement of equivalent urea		46.4	39.6

Urea consumption and imports from 1991 to 1998 are tabulated below.

Table 2.14 Urea imports by India (1991-98)

Years	Urea Consumption	Urea Imports	Percentage
	(in million tonnes)		
1991-92	14.00	0 39	3
1992-93	14.91	1 86	12
1993-94	15.81	2.78	18
1994-95	17.11	2.87	17
1995-96	17 91	3 79	21
1996-97	19.03	2.30	12
1997-98	20 56	2 39	12

Source. Fertilisers Pricing Committee

In recent years, the import of urea has been around 10% of the consumption. Keeping imports down to this level would be desirable on grounds of food security but this would imply a domestic production capacity of 41 million tonnes by 2012. This is not realistic. If all the four units now held up for approval (Thal, Nellore, Gorakhpur and Hazira) are all cleared and the Oman project comes on stream, we will have an additional capacity of 4.5 million tonnes. The proposed LNG projects at Ennore, Dabhol/Trombay and Dahej could support another four units. Thus the urea production capacity could rise to around 30 million tonnes by 2012.

An attempt to import 16 million tonnes would certainly increase prices and the demand may well come down to 40 million tonnes. This could be a likely scenario – 30 million tonnes produced and 10 million tonnes imported.

We assume that 635 cubic metres of natural gas is required to produce one tonne of urea. Consequently, 52 MMCMD of gas would be required in 2012 to produce 30 million tonnes of urea.

Urea demand projections for Andhra Pradesh

Andhra Pradesh is one of India's leading agricultural areas and one of the main rice producing areas in the country. The urea application is over 140 kg/ha compared to the national average of 75 kg/ha. The major fertiliser using crops are rice, sugarcane, cotton and groundnut. Three techniques have been used to project urea demand till 2015:

- Based on area and yield of rice
- 6 per cent projected official rate of growth of production of rice
- Trend analysis

<u>Based on area and yield of rice</u>

The gross cropped area and gross irrigated area under rice in Andhra Pradesh since 1991-92 are shown below.

Table 2.15 Area under rice in Andhra Pradesh

Year	*Rice*		
	Gross cropped area (GCA)	Gross irrigated area (GIA)	GIA as a % of GCA
	000 hectares	000 hectares	
1991-92	3936	3736	95%
1992-93	3604	3405	94%
1993-94	3547	3369	95%
1994-95	3638	3445	95%
1995-96	3692	3500	95%
1996-97	4109	3928	96%

Source. CMIE

The State Government plans to increase the irrigated area in Andhra Pradesh from the present 4 lakh hectares to about 9 lakh hectares by 2015. Going by past experience, such expansion plans seem highly overoptimistic. Based on discussions with the ministry of agriculture, the additional area coming under irrigation for all crops in the state by 2015 has been taken as 2.5 lakh hectares. Going by the present ratio, 67.9 % of this should come under rice. It is assumed that the yield of rice would increase from the current level of 2781 kg/ha to the level of 3443 kg/ha, already achieved in Tamil Nadu which has the best yield of rice in India today. With these assumptions, the fertilizer requirement for AP is computed using the same method as in the case of India.

Table 2.16 Projection of urea consumption in Andhra Pradesh based on yield of rice

Gross Cropped Area under Rice (hect) 1996-97	4,109,000	
Additional Irrigation Planned (hect)	250,000	
Ratio(GIA rice/GIA total) 1996-97	0.679	
Total Production of Rice (tons) 2015-16	14,731,736	
Present production of Rice (tons) 1996-97	10,686,000	
Additional Production of Rice (tons) 2015-16	4,045,736	
	Assumption 1	Assumption 2
Additional Fertilizer Consn for Rice (tonnes) 2015-16	539,432	404,574
Additional Fertilizer Consn for all crops (tonnes) 2015-16	899,053	674,289
Present fertilizer consn (tonnes) 1996-97	1,769,000	1,769,000
Total fertilizer consn (tonnes) Projected 2015-16	2,668,053	2,443,289
Total Nitrogen consn (tonnes) 2015-16	1,692,635	1,550,044
Urea Consumption 2015-16	3,046,744	2,790,079
Current Urea Consumption 1996-97	1,979,244	1,979,244
CAGR	2.3%	1.8%

Based on 6 % projected official rate of growth of production of rice

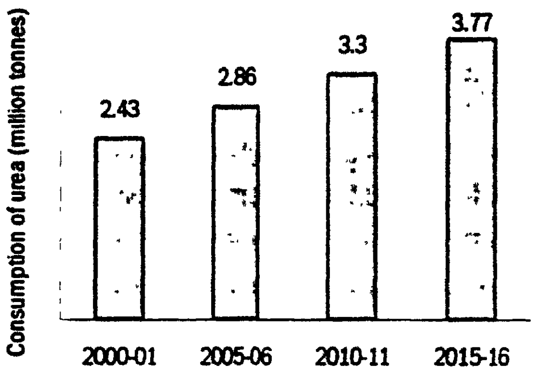
Table 2.17 Projection of urea consumption in Andhra Pradesh based on 6% growth of rice

Production of rice (000 tonnes)	1996-97	10,686	
Production of rice (000 tonnes)	2015-16	32,332	
Additional Production of Rice (tonnes)	2015-16	21645556	
		Assumption 1	**Assumption 2**
Additional Fertilizer Consumption for Rice (tonnes)		2,886,074	2,164,556
Additional Fertilizer Consumption (tonnes)		4,810,124	3,607,593
Present Fertiliser Consumption (tonnes)		1,769,000	1,769,000
Total Fertilizer Consumption (tonnes) Projected		6,579,124	5,376,593
Total Nitrogenous Fertilizer Consumption (tonnes)		4,173,853	3,410,957
Urea Consumption	**2015-16**	**7,512,935**	**6,139,722**
Current Urea Consumption	**1996-97**	**1,979244**	**1,979,244**
CAGR		**7.3%**	**6.1%**

Trend analysis

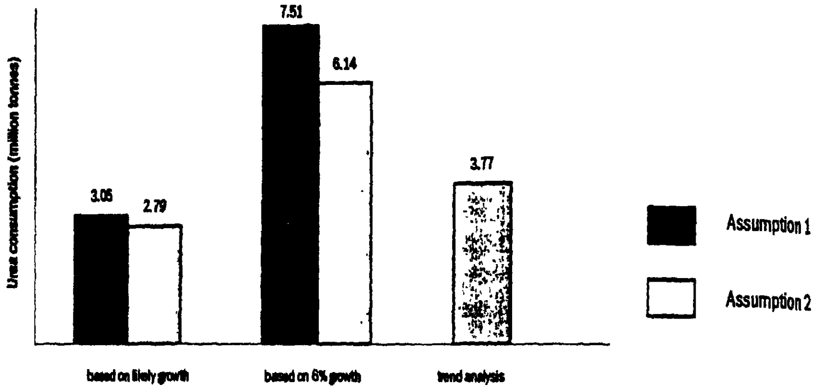
Consumption of nitrogen has been regressed against production of rice, cotton and groundnut, over the period 1979/80 to 1996/97 to forecast the consumption of nitrogen from 2000/01 to 2015/16. The projected future trends in urea use have been shown in Figure 2.5.

Figure 2.5 Projected trends in consumption of urea



The three methods yield the following results:

Figure 2.6 Projections of urea consumption in 2015-16



The second method based on the official projections is considered too high. Going by the other two estimates, consumption of urea in the state would increase to about 3 million tonnes by 2015. However, the entire urea consumption in the state need not be produced in the state. It can be sourced from other states or imported from the Middle East and Central Asia regions.

Urea is now a controlled product. A maximum price of Rs. 4,600/MT is payable by the farmers. Urea producers are paid a 'retention price' based on their cost of production. As the average cost of production is greater than the retail price of urea, the deficit has to be met by a government subsidy. The burden of fertiliser subsidies on the budget of central government has grown dramatically over the years from Rs. 505 crores in 1980/81 to Rs. 13,244 crores in 1999/00. Driven by the increasing subsidy, the government is considering a phased decontrol of urea prices. The Expenditure Reforms Commission has recommended a complete decontrol of the urea price by April 2006. Earlier attempts by the government to decontrol the urea price were not successful and it is not clear if the government can accept this recommendation. Unless a decision is taken on urea pricing, future demand will be uncertain and the government has decided not to sanction any additional capacity before 2003. For the same reasons, no additional capacity is likely in the private sector.

A proposal of the Indian Farmers Fertilizers Co-operative Limited (IFFCO) to set up a fertiliser plant at Nellore is at an advanced stage of consideration in the government. We believe that government approval for this project would be forthcoming if the unit could tie up LNG supply. In projecting the gas demand profile for the fertiliser sector, we assume that this plant with a gas demand of 1.8 MMCMD will come up in 2006.

Table 2.18 Gas demand for urea production till 2015

Year	Gas demand (MMCMD)
2001	2 75
2005	2.75
2006	4 55
2010	4 55
2015	4 55

Gas demand for industries

Existing and potential demand

The fuel consumption by industrial units in the state is available from the Annual Survey of Industries done by the Central Statistical Organisation. The latest available figures for 1996-97 are given in Annexure 2.1.

The gas demand can be estimated by converting coal, FO and LPG consumption on calorie equivalence. The calorific values assumed for the fuels are listed below.

Table 2.19 Calorific value of fuels

Fuel	Calorific Value
Coal	4800 Kcal/Kg
Fuel Oil	10440 Kcal/Kg
LPG	11300 Kcal/Kg
Fuel Wood	4000 Kcal/Kg
Natural Gas	8500 Kcal/m^3

The fuel consumption has been added up only for the sectors which are using an appreciable amount of gas or are considered capable of using a substantial amount of gas. Fuel consumption for electricity generation in Annexure 2.1 has not been considered as gas demand for the power sector has been dealt with separately. Also, LPG used for welding/cutting in the metal industry has not been considered, as there may be some difficulty in using natural gas for these applications. Coal used by basic metal and alloys is mainly in manufacturing sponge iron. This also cannot be replaced by gas. Fuel wood consumption has not been considered, as this is limited to small units.

The Vision 2020 of the Andhra Pradesh government projects the growth rate of the industrial sector as:

Table 2.20 Targeted growth rate of the industrial sector in Andhra Pradesh

Period	Growth Rate (%)
1995-2000	5.3
2000-2005	9.7
2005-2010	11.6
2010-2015	13.8
2015-2020	14.6

Andhra Pradesh is one of the leading states in cement and paper production owing to the huge limestone deposits and availability of pulp. It has 20% of India's limestone reserves. These industries should continue to provide the bulk of the fuel demand in the state. Future industrial growth will be higher in the non-energy intensive categories. Based on discussion with the cement, pulp and paper and glass and ceramic industries, a 6% annual growth rate has been assumed for these energy intensive industries. It has accordingly been assumed that energy consumption in industry will grow at 6% per annum.

Industrial gas demand inflated at 6% from the actuals available for 1996-97 is projected below.

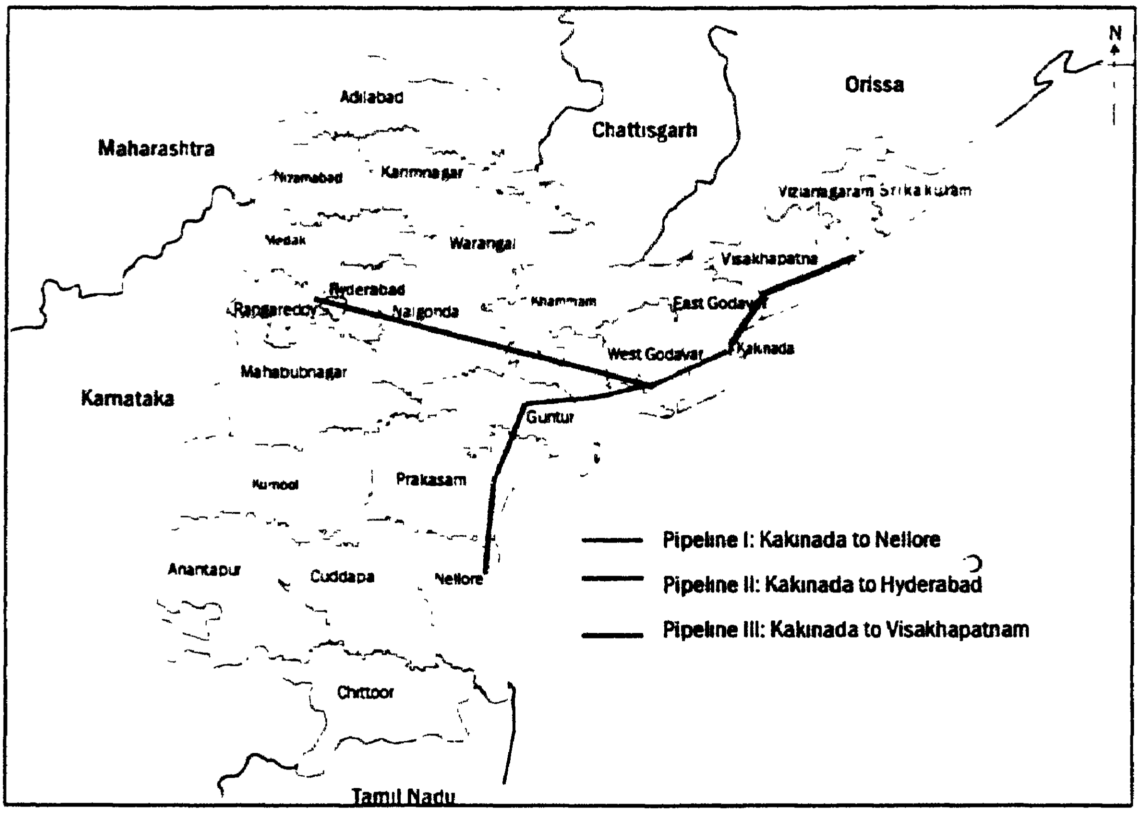
Table 2.21 Gas demand from industrial units till 2015

Year	State (MMCMD)	Along Pipelines (MMCMD)
2001	7.31	5.70
2005	9.22	7.19
2010	12.34	9.63
2015	16.52	12.88

This methodology overstates the gas demand for two reasons. All the units cannot change over to gas. Only the large and medium sized units can afford to change over to gas. No data is available on the proportion of such units in the state. Also, the conversion based on calorie values does not capture the differences in the efficiency of fuel for different fuels. The efficiency of gas-burners is expected to be higher than existing burners.

On the basis of the proposed anchor loads (power and urea plants), and the important industrial clusters, three pipelines from the import terminal at Kakinada has been considered, as shown in Figure 2.7.

Figure 2.7 Possible Pipeline Alignments from Kakinada



The district-wise break up of fuel use is available only for fuel oil (Annexure 2.2). This shows that the districts along the pipelines (Visakhapatnam, East and West Godavari, Krishna, Guntur, Prakasam, Nellore, Khammam, Warangal, Nalgonda, Mehboobnagar, Hyderabad, Rangareddy and Medak) use 78% of the fuel oil used in the state. The same ratio has been assumed for all fuels to estimate the equivalent gas demand in the districts along the pipelines.

The sponge iron industry is an important gas consumer in the country. The gas based units have come up in the west where gas is available. These units use iron ore from eastern Madhya Pradesh. The ore passes through Andhra Pradesh on the way to western India by sea. A gas based sponge iron unit in Andhra Pradesh would be favourably placed compared to units in western India and would make sense when imported scrap prices are buoyant. However, in the absence of any concrete proposal, no demand has been assumed from this sector.

The Andhra government is keen to promote a large industrial estate near Kakinada where gas would be used as feedstock to produce a number of medium-value chemicals. The Indian Institute of Chemical Technology is

preparing a project report. The gas demand from this project can be estimated only after the project takes a definite shape.

Survey results

Thirty-six units belonging to the paper, cement, sugar, textile and pharmaceutical industries were visited to ascertain their willingness to change over to gas and to estimate the gas demand. There is no comprehensive data base giving the type, size and locations of industries in the state which can be used to draw a sample for survey. Lists were obtained from the Commissioner of industry, the Andhra Pradesh Industrial Development Corporation and industry associations. An attempt was made to cover all the districts along the possible pipeline alignments and to cover all the important energy intensive industry types in the survey.

The gas demand from the surveyed industries is shown in the Table below:

Table 2.22 Gas demand from surveyed industrial units

District	*Type of industry*	*Demand (MMCMD)*
Anantapur	Cement	0.684
East Godavan	Refractones, Ceramics, Paper and Sugar	0.259
Guntur	Cement	0.177
Hyderabad	Glass and Ceramics and Others	0.037
Khammam	Paper	0.142
Knshna	Cement	0.219
Medak	Refractones	0.003
Nalgonda	Cement	0.784
Ranga Reddy	Paper and Textiles	0.067
Vishakhapatnam	Cement	0.239
Warangal	Paper	0.025
West Godavari	Sugar	0.007
Total demand from surveyed units is 2.64 MMCMD		

Information obtained from these units are being sent separately. In evaluating the gas demand from these units, the ferro-alloys, pharmaceuticals and chemical industries have not been considered as it will not be cost effective for them to switch over to gas. The current and projected gas demand from the surveyed units has been shown in Tables 2.22 and 2.23.

Table 2.23 Projected gas demand from surveyed industrial units

Year	Demand (MMCMD)
2001	2.64
Up to 2005	2.86
2010	3.83
2015	5.12

As noted earlier, the gas demand figures as presented in Table 2.21 are overestimates and will distort the picture if these are included in the total demand. Accordingly, in computing the total demand for the state, we consider only the demand from the surveyed units. To project gas demand from industries beyond 2005, we apply a 6% growth rate to the demand for 2005 indicated by the surveyed units.

Gas demand for captive power generation

The "1999 Captive Report" published by Powerline gives the break up of captive generation in Andhra Pradesh for 1998 as follows:

Table 2.24 Captive generation by fuel type in 1998

Fuel Type	Capacity (MW)
Steam	689.6
Diesel	575.6
Gas/Naphtha	45.2
Hydel	2.00
Total	1312.4

Source. Powerline

Existing and potential gas demand

For 2001, only naphtha/gas based units have been considered for computing the gas demand, as coal/diesel based captive generators cannot changeover to gas profitably. For gas based generation, a PLF of 22% has been assumed as per information obtained from APGENCO as shown in Annexure 2.3. It has been assumed that captive gas based generators would operate as open cycle plants with an efficiency of 35%.

For projecting gas demand to 2005, it is assumed that total captive capacity will grow at an annual rate of 6% (as industrial growth is assumed at 6%) and all additional capacity from 2001 will be gas based. It is further assumed that there will be no growth in captive capacity beyond 2005 as the power supply position is expected improve.

Based on the above assumptions, gas demand for captive generation has been projected till 2015. This is presented in Table 2.25.

Table 2.25 Gas demand for captive generation till 2015

Year	State (MMCMD)	Along Pipelines (MMCMD)
2001	0.08	0.08
2005	1.30	1.01
2010	1.30	1.01
2015	1.30	1.01

As observed in the case of fuel oil and assumed for other fuels used by industry, it is assumed that 78% of the demand for captive generation will come from industrial units along the pipeline routes.

Gas demand for city distribution

There is no operating local gas distribution network in Andhra Pradesh at present. However an allocation of 0.1 MMCMD has been made by the government for gas use for domestic and commercial purposes. The Indraprastha Gas Limited, a subsidiary of GAIL which now runs the Delhi city gas distribution project, has proposed to take up local distribution in the following towns/cities in Andhra Pradesh:

Table 2.26 City distribution planned by Indraprastha Gas Limited

Kakinada	Tanuku	Palakolluz
Rajahmundry	Tuni	Narsapur
Amalapuram	Ramachandrapuram	Vizag
Mandapeta	Bhimavaram	Elamanchili
Total estimated demand by IGL is 5.8 MMCMD		

Source. IGL

Potential gas demand

To estimate the demand for city distribution, 25 largest urban agglomerations in the state have been considered. The population in these agglomerations have been projected based on estimates made by the noted demographer Ashish Bose. Annexure 2.4 shows the urban agglomerations in the state and their projected population. Five people per household has been considered, hence the number of households is one-fifth of the population at any point of time.

At present, the coverage of households by LPG in India is around 25%. With unrestricted availability of LPG and rising incomes, the coverage is likely to increase as below:

— 55% in 2005

— 65% in 2010

— 75% in 2015

The expected penetration of natural gas into households using LPG is 40% in 2005, 50% in 2010 and 60% in 2015. These estiomates are based on the experience gained in the Mumbai and Delhi city gas distribution projects.

In view of the above assumptions, gas demand in the state and in districts along the possible pipeline alignments have been estimated as presented in Table 2.27. The gas demand per day per household has been taken to be 1 cubic metre. In computing the demand along the pipelines, all agglomerations falling in the concerned districts have been considered.

Table 2.27 Projected gas demand for city distribution

Year	State (MMCMD)	Along Pipelines (MMCMD)			Total
		(I)	(II)	(III)	(MMCMD)
2005	0.75	0.21	0 47	0.12	0.62
2010	1.31	0.37	0 80	0.21	1.07
2015	2 04	0 58	1 26	0.33	1 67

Note. Demands along pipelines do not add up to total due to overlaps

Considering that the Mumbai project started in 1996 uses only 0.3 MMCMD today, it is obvious that there would be serious practical constraints in reaching such volumes of supply.

Andhra Pradesh

3 Gas demand-supply deficit

The future availability of gas in Andhra Pradesh is projected by ONGC as below.

Table 3.1 Gas availability projections from K-G basin

Year	*Total Gas (MMCMD)*
2001-02	8.572
2002-03	8.527
2003-04	8.162
2004-05	7.319
2005-06	6.833
2006-07	6.092
2007-08	3.436
2008-09	2.852
2009-10	1.737
2010-11	0.939
2011-12	0.757
2012-13	0.670
2013-14	0.545
2014-15	0.520

Source. Global energy in sight

It may be noted that existing gas supply contracts do not have penalties for short supply although consumers can be penalised for short lifting. This gives ONGC an inducement to overestimate supply rather than underestimate it. However, based on our discussions with ONGC and GAIL we believe that the probability of supplies falling below the projected levels is low.

On the other hand, the availability figures are conservative as they are based only on known reserves. Some new gas discoveries have been reported after the numbers in Table 3.1 were worked out and the availability could be revised upward. However, the extent of revision may not be large.

ONGC has found a lot of gas in the area recently and exploration is on. This area has accordingly attracted the maximum interest in the first round of bidding under the New Exploration Licensing Policy. Out of the 25 blocks awarded in the country, 9 are in this area. Of the $1200 million investment planned in the 25 blocks, $600 million is for blocks in this area. All this has understandably produced an expectation of additional gas supplies. The situation would be clearer by 2003, the end of phase-I of the exploration

contracts. It would be difficult to get customers to sign up for LNG before that date as they would prefer to wait for cheaper gas to be discovered.

As to other possible sources of supply, there is a possibility of getting Bangladesh gas into Andhra Pradesh. A 1 bcfd project with an onshore pipeline hugging the east coast could deliver gas at Kakinada at $3.0/ MMBTU. However, the Bangladesh government has not yet agreed to export gas to India. Some gas could also be available in the southern part of the state from the Ennore LNG terminal in Tamil Nadu. Nellore was selected as the location for IFFCO's proposed urea plant on this expectation. Some LNG projects in the neighbouring state of Orissa have also been proposed but none of them have made any progress. We see no need as yet to consider them as gas sources for Andhra Pradesh.

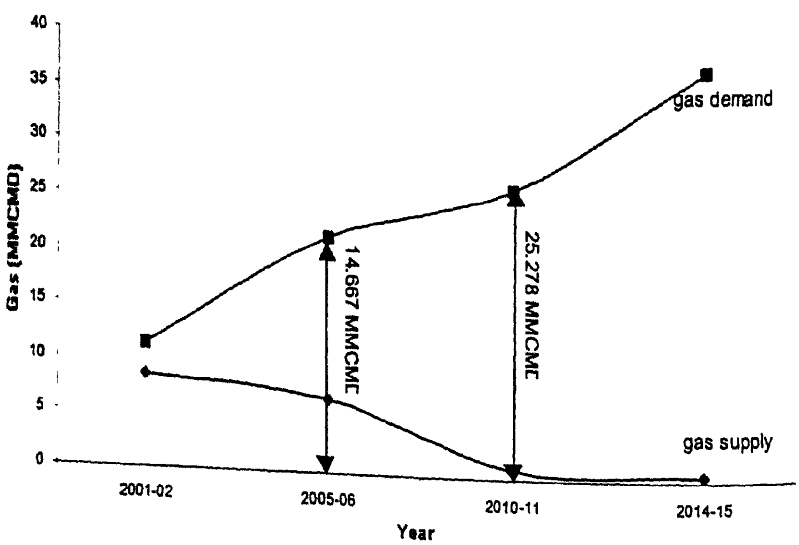
The sectoral gas demand as assessed in the previous chapter has been summarised in Table 3.2.

Table 3.2 Time profile of gas demand

Year	*Power*	*Fertiliser*	*Captive*	*Industrial*	*City distribution*	*Total*
2001	5.86	2.75	0.08	2.64	0	11.33
2005	14.26	2.75	1.01	2.86	0.62	21.5
2010	15.76	4.55	1.01	3.83	1.07	26.22
2015	24.76	4.55	1.01	5.12	1.67	37.11

Based on this demand profile and the availability projections in Table 3.1, the gas deficit in 2005 and 2010 works out to be 14.67 and 25.28 MMCMD respectively. This has been presented in Figure 3.1 below.

Figure 3.1 Time profile of gas demand and availability



The sectoral break-up of the deficits in 2005 and 2010 are estimated below. In this it has been assumed that the supplies to the sectors will be proportionate to the allocations as shown in Chapter 1.

Table 3.3 Gas demand-supply deficit in 2005

Sector	*Demand*	*Domestic Supply*	*Allocation*	*Deficit*
Power + captive generation	15.27	5.22	11.06	10.05
Urea production	2 75	1.30	2.75	1.45
Industries	2 86	0.22	0.46	2.64
City distribution	0 62	0.10	0.10	0.52
Total	**21.50**	**6.83**	**14.36**	**14.67**

Table 3.4 Gas demand-supply deficit in 2010

Sector	*Demand*	*Domestic Supply*	*Allocation*	*Deficit*
Power +captive generation	16.77	0.65	11.06	16.12
Urea production	4 55	0.16	2.75	4.39
Industries	3.83	0.03	0.46	3.80
City distribution	1.07	0.10	0.10	0.97
Total	**26.22**	**0.94**	**14.36**	**25.28**

4 Imputed values

Methodology

The imputed value of gas is the price of gas at which the cost of generation or production in a gas based plant equals the cost of generation/production using an alternative fuel, at a particular location. Thus it indicates the maximum price for gas at which it is competitive with the cheapest alternative fuel. The methodology used has been illustrated in Table 4.1 below.

Table 4.1 Methodology for calculating imputed value of gas

Cost of generation/production	Gas based	Competing technology
Capital cost	a	c
Operation and maintenance cost	b	d
Fuel cost	X (unknown)	e
Total cost		f = c + d + e
Imputed value of gas		X = f - a - b

Power generation

In India, domestic coal has the largest share in total installed capacity. The use of imported coal for power generation is also increasing. Accordingly, both domestic and imported coal have been considered for calculating the imputed values of gas in power generation, at each reference location indicated in Table 4.2 below.

Table 4.2 Locations for imputed values in power generation

Location	Nearest station
Existing power plants	
Jegurupadu	Samalkot
Vijjeswaram	Rajahmundry
Kakinada	Samalkot
Kondapalli	Vijaywada
Proposed power plants	
Peddapuram	Samalkot
Vemagiri	Rajahmundry
Konaseema	Rajahmundry
Bhimavaram	Samalkot
Krishnapatnam	Nellore

These are the loactions where new/expansion projects could come up.

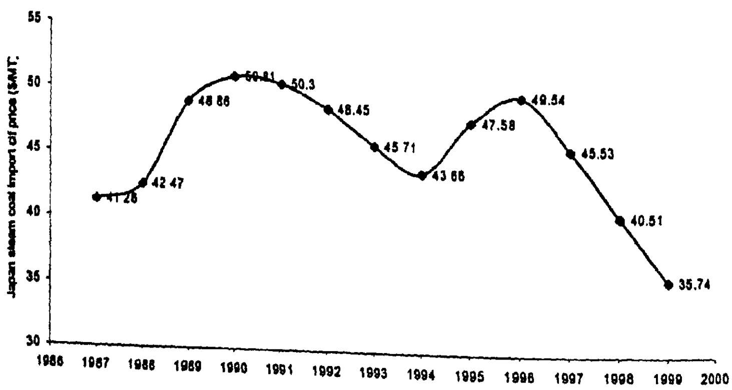
Capital cost per unit of power, including interest during construction (IDC) are annuitised using the capital recovery factor which is determined by the operating life of the project and the discount/interest rates. Annual generation, determined by the plant load factor (PLF) minus the auxiliary consumption gives the net units sent out in a year. These together provide the capital cost per unit of electricity sent out which along with the O&M costs and the fuel costs per unit give the total cost of generation of a unit of electricity.

Fuel costs

Imported coal

The cif price of steam coal imported into Japan has varied within the band of $ 40-50 /MT over 1987-1999 (Figure 4.1).

Figure 4.1 Trends in long term coal prices: Japan steam coal cif price ($/MT)



Source. BPAmocoalive 2000

1999 was the first year in which the price dipped below $40/MT. As on October 18, 2000, it was $34/MT. Indian cif prices have been close to the Japanese cif prices. For imputed value estimations, two values of cif prices of imported coal at Kakinada port have been considered: $34/MT and $40/MT.

The landed cost is shown in Annexure 4.1.

The railway freight to the nearest railway station from Kakinada has been taken as per the Indian Railway Conference Association: Goods Tariff No. 42. No escalation in freight for future years has been considered. The landed cost and transoportation costs together give the delivered costs of imported coal at the locations considered. These are given in Annexure 4.2.

Indigenous coal

Production from the Godavari Valley coalfields of Andhra Pradesh is not expected to increase in future. So, supply of power grade coal from Talcher fields in Orissa has been considered.

Indigenous coal prices have been decontrolled from January 2000 . These prices are now determined by Coal India Limited (CIL). No indications from CIL are available on how the prices will move in future.

The long run marginal cost (LRMC) of production of domestic power-grade coal from Talcher has been estimated at Rs 540/MT[b]. The current power grade coal price (without taxes) from Talcher is much lower at Rs 361/MT. It is assumed that the price of coal will reach the LRMC in the long run. Rs. 50/MT of royalty, Rs. 3.50/MT of excise and 4% CST has been added to the LRMC cost to project the price of coal from Talcher. Transportation costs and delivered prices of domestic coal from Talcher to various power plant locations have been shown in Annexure 4.2

Technical and financial parameters

Imported coal has a higher calorific value (6400 kcal/kg) than domestic power grade coal (4000 kcal/kg) but imported coal has a greater sulphur content. We have assumed that a plant based on imported coal will be required to install a flue gas desulphurisation unit at an additional capital cost of about Rs. 4 million/MW.

Till date India has operated only subcritical coal based power plants. Though NTPC plans a 660 MW supercritical coal power plant at Seepat by 2006-07, India as yet has no experience of supercritical coal plants. Hence in this analysis only subcritical coal power plants has been considered. A typical pulverised subcritical coal based power plant has an efficiency of about 34% compared to 50% for a gas-based plant. The technical and financial parameters of steam turbines and combined cycle gas turbines are based on views of officials from the National Thermal Power Corporation (NTPC) and Central Electricity Authority (CEA).

[b] Source. Environmental issues in the power sector – UNDP ESMAP

Table 4.3 Technical and Financial Parameters for Steam Turbine Plants

Technical parameters	*Units*	*Value*
Plant load factor	%	75
Auxiliary consumption (indigenous coal)	%	9.5
Auxiliary consumption (imported coal)	%	7.5
Life of plant	Years	35
Calorific value (indigenous coal)	kcal/kg	4000
Calorific value (imported coal)	kcal/kg	6400
Heat rate per unit sent out (indigenous coal)	kcal/kWh	2762
Heat rate per unit sent out (imported coal)	kcal/kWh	2703
Financial parameters	*Units*	*Value*
Discount rate	%	12
Capital cost per MW (indigenous coal based)	Rs. Million	40
Capital cost per MW (imported coal based)	Rs. Million	44
Fixed operating cost as % of capital cost	%	2.5
Investment period	Years	4

For sensitivity of imputed values, another value for the heat rate of coal-fired plants at 2450 kcal/kg has also been considered.

Table 4.4 Technical and Financial Parameters for Combined Cycle Plants

Technical parameters	*Units*	*Value*
Plant load factor	%	75
Auxiliary consumption	%	3
Life of plant	Years	20
Calorific value	kcal/Nm^3	8500
Heat rate per unit sent out	kcal/kWh	1709
Financial parameters	*Units*	*Value*
Discount rate	%	12
Capital cost per MW	Rs. Million	30
Fixed operating cost as % of capital cost	%	2.5
Investment period	Years	3

The heat rate of 1709 kcal/kwh taken above has not been achieved yet in India but is considered achievable.

Imputed values of gas in Power Generation

The imputed values of gas at the reference power plant locations have been tabulated below. The detailed calculations are at Annexure 4.3 – 4.6.

Table 4.5 Imputed values of gas in power generation

Location	Imputed values of gas ($/MMBtu)					
	Domestic coal		Imported Coal			
	Heat rate: 2500 Kcal/kWh Economic prices	Heat rate: 2450 Kcal/kWh Economic prices	Heat rate: 2500 Kcal/kWh		Heat rate: 2450 Kcal/kWh	
			$34/MT	$40/MT	$34/MT	$40/MT
Samalkot	3.60	3.54	4.49	4.95	4.43	4.87
Rajahmundry	3.67	3.62	4.49	4 95	4.43	4.87
Vijaywada	3.92	3.86	4.57	5.02	4.50	4.95
Nellore	4.34	4.27	4.81	5.26	4.74	5.18

Urea production

Imputed values of gas in urea production have been estimated at Samalkot near Kakinada where the NFCL plant exists, Nellore where the IFFCO plant has been proposed and Visakhapatnam, a possible location for a future plant.

Naphtha and fuel oil are possible alternatives to gas but the cost of urea production with these fuels will be higher under all circumstances. Imputed values have accordingly been estimated against imported urea.

Table 4.6 Locations for imputed values in urea production

Location	*Landing port for imported urea*
Existing fertiliser plant	
Kakinada	Kakinada
Proposed plant/Likely location	
Nellore	Kakinada
Visakhapatnam	Visakhapatnam

Technical and financial parameters

The following technical and financial parameters of gas based urea plants conform to views of the Fertiliser Association of India (FAI) and assumptions of the High Powered Committee on Fertilizer Pricing Policy.

Table 4.7 Technical and financial parameters of a typical gas based urea plant

Parameter	*Unit*	*Value*
Technical parameters		
Urea capacity	Tons/year	726,000
Energy required per ton of urea	Gcal/ton	5.40
Calorific value of gas	kcal/Nm^3	8500
Life of plant	Years	15
Financial parameters		
Discount rate	%	12
Capital cost (new plant)	Rs. Million	17,000
Capital cost (expansion plan)	Rs. Million	15,000
Fixed operating cost	Rs/Ton	854
Investment period	Years	3

Price of urea

The cif price of imported urea has fluctuated widely in the past depending critically on purchases made by India and China. The international urea prices from 1971 to 1998 are given below.

Table 4.8 International urea price at current price

Year	Price at current $ (per MT)	Year	Price at current $ (per MT)	Year	Price at current $ (per MT)
1971	46.00	1980	222.10	1989	132.20
1972	59.30	1981	216.00	1990	157.00
1973	94.80	1982	158.80	1991	172.00
1974	315.80	1983	135.40	1992	140.30
1975	198.00	1984	171.30	1993	106.75
1976	112.00	1985	136.30	1994	147.92
1977	127.40	1986	107.00	1995	211.50
1978	144.80	1987	116.60	1996	205.48
1979	172.90	1988	155.00	1997	103.00
				1998	91.00

Source. EPW July 1999

A cif price of $150/MT is usually taken as the average. The landed cost of imported urea at the Indian port with a cif price of $ 150/MT, an exchange rate of Rs 46.36 per US dollar and no duty is Rs 6954/MT.

Imputed values of gas in urea production

Imputed values of gas against urea imports have been calculated for zero import duty. Table 4.9 provides the results. The details have been annexed at Annexure 4.7.

Table 4.9 Imputed values of gas against urea imports at cif $150/MT

Location	Imputed values ($/MMBtu)
Visakhapatnam	2.07
Samalkot	2.07
Nellore	2.40

These values are below even domestic gas prices. No import of gas could be feasible anywhere in India at such prices.

It is evident, therefore, that no new fertiliser capacity can come up without import duty. On food security considerations, that would not be desirable. The government therefore may impose a duty or allow a subsidy/concession to new units. The Expenditure Reforms Commission has recommended Rs 1,900/MT to be allowed as concession to new units based on LNG while the farmgate price paid by the consumer is pegged at Rs 7000/ MT. In that case, the producer would receive a net price of Rs. 8,600/MT after deducting Rs 300/ MT as the

marketing cost. The imputed value of gas against this producer price is $ 3.73/MMBtu. This is for new units set up at any location. For existing/ expansion plants the imputed values would be higher. Details are presented at Annexure 4.8.

Industries and city distribution

Industrial clusters and towns along the possible pipeline alignments have been considered for imputed value estimation.

Table 4.10 Locations for imputed values in industries and city distribution

Location	*Nearest railway station*
Visakhapatnam	Visakhapatnam
Kakinada	Samalkot
Vijaywada	Vijaywada
Nellore	Nellore
Hyderabad	Hyderabad

Cement, Paper, Refractories, Glass and Ceramics are the major energy intensive industries in the state, using D-grade coal, LPG, furnace oil, etc. LPG is the domestic fuel to be replaced by gas.

Fuel costs

Fuel oil and LPG

These fuels are priced on import parity basis. The fob-Middle East FO and LPG prices have been regressed against fob-Middle East crude oil prices over March 1996 to June 2000 to assess the prices of these fuels when crude oil prices are at $16/bbl, $20/bbl and $25/bbl.

The insurance, sea freight charges, import duties and port storage and handling charges are added to the fob price to derive the landed cost of FO and LPG at Visakhapatnam port. The customs and countervailing duty conform to the Expert Technical Group recommendations accepted by the government. The details of landed cost for FO and LPG have been shown in Annexures 4.9-4.10 and the delivered prices are in Annexure 4.11.

Domestic coal

Average calorific value of domestic coal for industrial use is assumed to be 4,800 kcal/kg. Talcher does not produce any D grade coal, so supplies from Ib Valley (Orissa) have been considered. The price of D-grade coal, as in April 2000, from Ib valley is Rs. 699.40/MT. The long run marginal cost of production of power

grade coal as quoted earlier is Rs. 540/MT. The LRMC for D-grade coal has been estimated at Rs. 1008.29/MT by taking the proportion of current prices. The delivered prices of coal from Ib at the selected locations have been shown in Annexure 4.11.

Imputed values of gas as industrial and domestic fuel

Imputed values of gas for industrial applications and city distribution have been computed on calorie equivalence. The imputed values for city distribution refer to burner–tip prices.

Table 4.11 Imputed values for industries and city distribution

Location	*Imputed values ($/MMBtu)*						
	FO			LPG			Domestic coal
	crude $16/bbl	crude $20/bbl	crude $25/bbl	crude $16/bbl	crude $20/bbl	crude $25/bbl	At LRMC
Visakhapatnam	3.14	3.92	4.89	6.18	7.46	9.06	1.62
Samalkot	3.30	4.08	5.05	6.31	7.59	9.19	1.74
Rajahmundry	3.34	4.12	5.09	6.34	7.62	9.22	1.79
Vijaywada	3.48	4.26	5.22	6.45	7.73	9.33	1.92
Nellore	3.71	4.49	5.46	6.64	7.92	9.52	2.12
Hyderabad	3.81	4.59	5.55	6.72	8.00	9.60	2.21

The estimates have been detailed out in Annexures 4.12-4.14. This method does not capture differences in technology and therefore underestimates the imputed values. Even the present gas price paid (Rs. 2150-2850/thousand cubic metres) is higher than imputed values against domestic coal at some of the locations. However, it is clear that industrial units would be able to use imported gas only if there is significant upgradation in technology.

5 Price profile of demand

Imputed values of gas have been used along with the sectoral gas deficits estimates from chapter 3 to arrive at the price profiles of gas demand in 2005 and 2010, presented in Figure 5.1 and 5.2 respectively.

Imputed values for industry and power generation have been taken against domestic coal. For urea production, a net realisation of Rs 8,600/MT of urea produced has been considered. The imputed values taken are for locations around Rajahmundry.

Figure 5.1 Price profile of gas demand in 2005

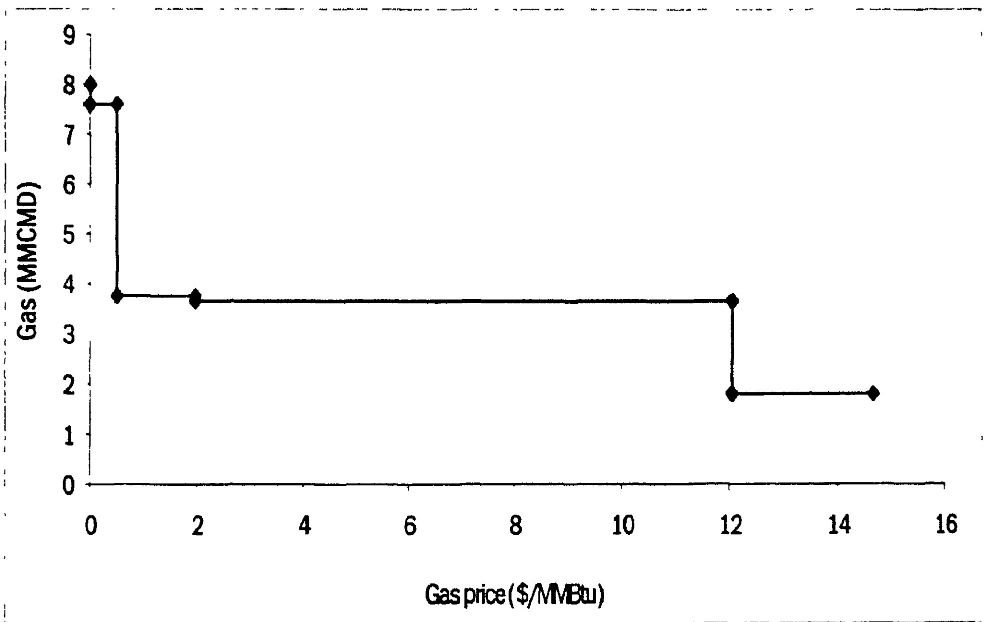
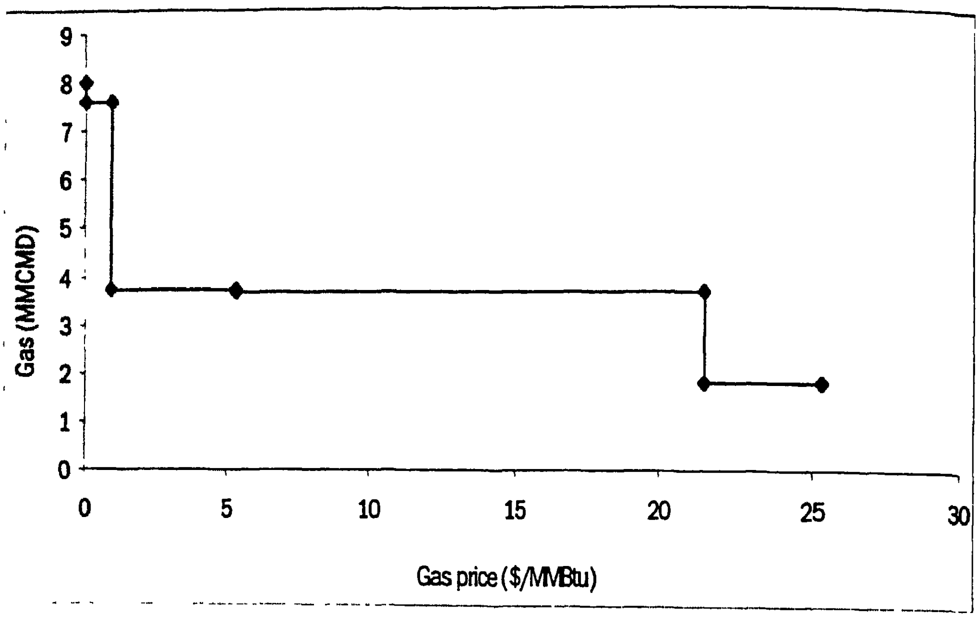


Figure 5.2 Price profile of gas demand in 2010



The estimated gas demand and the projected supply point to an increasing deficit. The deficit reaches 15 MMCMD by 2005 and 25 MMCMD by 2010. Of these deficits, 12 MMCMD in 2005 and over 20 MMCMD in 2010 would be saleable at $ 3.5/ MMBTU. A better price could well be obtained as the customers would be partly using cheaper domestic gas.

Annexures

Annexure 2.1 Industrial Units Consuming Coal, Fuel wood, FO, LPG and Natural Gas

NIC codes	*Andhra Pradesh (1996-97)*	Coal (incl Coke) [Tonne]	Liquefied Petroleum Gas [Tonne]	Natural Gas [Th cu Metre]	Furnace Oil [Th litre]	Other Fuel Oil [Th.litre]	Fire Wood Incl charcoal [Tonne]
		Qty	Qty	Qty	Qty	Qty	Qty
40	Electricity	5569837		93680	2749	19453	-
32	Manufacture of Non-metallic mineral products	2791476	6316	389	73000	1287	6628
30	Manufacture of Basic chemicals and Chemical Products (except products of petroleum and coal)	230691	65	210036	120972	142	6835
33	Basic metal and alloys industries	352460	224	234	32700	39400	5444
20	Manufacture of Food Products	26001	356	3777	7498	1229	14178
28	Manufacture of Paper and paper products and printing, publishing & Allied Industries	686679	55	7084	11830	706	1249
23	Manufacture of Cotton Textiles	6752	1	-	203	18	661
21	Manufacture of other food products	84257	128	-	4586	816	18074
31	Manufacture of rubber, plastic, petroleum and coal products; processing of nuclear fuels	8133	7	-	13015	1241	1917
36	Manufacture of machinery and equipment other than transport equipment	4604	2291	7	5100	21	176
34	Manufacture of Metal products and parts, except machinery and equipment	3209	5303	140	3250	650	2029
35	Manufacture of machinery and equipment other than transport equipment	3946	791	96	557	1	22
37	Manufacture of Transport equipment and parts	334	229	-	2961	2229	1
24	Manufacture of Wool, Silk and Man-made Fibre Textiles	29689	-	-	30	1	1264
22	Manufature of Beverage, Tobacco and related products	19440	-	6665	1198	526	10703
39	Repair of capital goods	1130	-	-	500	232	-
26	Manufacture of Textile Products (including Wearing Apparel)	5762	-	-	-	17	811
25	Manufacture of jute and other vegetable fibre Textiles	36	-	-	-	2	-
38	Other manufacturing industries	361	5	26	411	2	270
29	Manufacture of leather and prdts. Of leather	1450	-	-	-	-	24
27	Manufacture of Wood and wood products; Furniture and Fixtures	371	-	-	-	3	17
97	Repair services	2	-	-	-	-	1

Annexure 2.2 Fuel oil sales in Andhra Pradesh

Furnace Oil Sale in Andhra Pradesh (in Metric Tonnes)

District Name	95-96	96-97	97-98	98-99	99-00
ADILABAD	1312.29	2985.96	6583.04	11538.74	19014.92
ANANTAPUR	145.62	44.81	1866.49	21719.86	28595.18
CHITTOOR	4350.98	5495.67	4797.21	5336.93	6983.04
CUDDAPAH	21723.02	13853.71	7977.4	3928.74	5020.79
EAST GODAVARI	3173.8	3076.8	4916.97	10975.66	13669.86
GUNTUR	3125.55	12543.89	11861.79	5441.64	5901.54
HYDERABAD	14871.26	14729.2	18966.27	29097.68	34987.47
KARIMNAGAR	12828.36	12533.49	20462.65	13111.13	3480.97
KHAMMAM	27458.8	33858.75	33997	38900.08	30552.5
KRISHNA	29891.6	24382.7	26991.77	26051.79	27651.09
KURNOOL	17354.72	20211.87	28506.03	40558.32	36433.58
KY RANGA REDDY	8623.44	11012.38	13013.25	17698.93	36331.72
MEDAK	22324.4	30317.24	37464.56	38381.24	45150.11
MEHBUBNAGAR	4725.42	6361.31	6181.51	5522.68	6217.07
NALGONDA	19971.49	26162.89	36654.92	41096.91	49416.54
NELLORE	9129.72	12660.1	7942.91	9364.93	10774.87
NIZAMABAD	224.06	780.1	2971.97	4247.86	190.44
PRAKASAM	793.58	781	2658.26	3819.76	4831.93
SRIKAKULAM	1152.64	1194.66	1558.74	2370.17	3110.48
VISAKHAPATNAM	43476.74	57973.76	91020.08	69435.21	107503.86
VIZIANAGARAM	11438.62	22774.96	26494.37	7487.8	4199.31
WARANGAL	690.47	686.75	5332.39	2378.1	1910.36
WEST GODAVARI	2747.35	3374.81	5047.1	3442.95	4155.2
Grand Total	261533.93	317796.81	403266.68	411907.11	486082.83

Annexure 2.3 Captive Generation in Andhra Pradesh

Captive Generation in Andhra Pradesh. 1998-99		
Name of the Circle	Capacity (KVA)	Energy (MU)
Srikakulam	12870	3.77
Vijaynagaram	47036	175.2
Vishakhapatnam	307930	2230.16
Rajahmundry	58517	117.68
Eluru	30445	27.3
Vijaywada	44945	123.87
Guntur	433591	57.48
Ongole	10770	11.49
Nellore	15215	13.49
Tirupathi	25370	13.5
Cuddapah	58500	65.9
Ananthapur	44675	115.58
Kurnool	61639	183.05
Mahaboobnagar	10155	27.04
Nalgonda	128221	223.76
Hyderabad (S)	16735	1.47
Hyderabad (N)	60878	35.73
Khammam	45935	250.91
Ranga Reddy	80762	200.46
Karimnagar	50700	123.53
Nizamabad	2225	0.02
Adilabad	64065	196.99
Medak	52092	72.1
Warangal	12040	68.37
Total	**1675311**	**4338.85**

Source: Power Development in Andhra Pradesh (1998-99) - APSEB

Annexure 2.4 Urban Agglomerations in Andhra Pradesh: Population in million

Urban Agglomerations	*Districts covered*	*Population '91*	*in '01*	*in '05*	*in '10*	*in '15*
Hyderabad	Hyderabad	4.280	5.842	6.614	7.723	8.727
Vishakhapatnam	Vishakhapatnam	1.052	1.436	1.625	1.898	2.145
Vijaywada	Krishna and Guntur	0.845	1.154	1.306	1.525	1.723
Guntur	Guntur	0.471	0.643	0.728	0.850	0.960
Warangal	Warangal	0.467	0.637	0.721	0.842	0.952
Rajahmundry	East Godavari	0.404	0.551	0.624	0.729	0.823
Kakinada	East Godavari	0.327	0.447	0.506	0.591	0.668
Nellore	Nellore	0.316	0.432	0.489	0.571	0.645
Kurnool	Kurnool	0.275	0.375	0.425	0.496	0.560
Nizamabad	Nizamabad	0.241	0.329	0.372	0.435	0.491
Cuddapah	Cuddapah	0.216	0.294	0.333	0.389	0.439
Ramagundam	Karimnagar	0.214	0.292	0.331	0.386	0.436
Eluru	West Godavari	0.213	0.291	0.329	0.384	0.434
Tirupati	Chittor	0.189	0.258	0.292	0.341	0.385
Vizianagaram	Vizianagaram	0.176	0.240	0.272	0.318	0.359
Anantapur	Anantapur	0.175	0.239	0.270	0.315	0.356
Machlipatnam	Krishna	0.159	0.217	0.246	0.287	0.324
Khammam	Khammam	0.149	0.203	0.230	0.268	0.303
Karimnagar	Karimnagar	0.148	0.202	0.229	0.268	0.302
Tenali	Guntur	0.144	0.196	0.222	0.260	0.293
Chirala	Prakasam	0.143	0.195	0.220	0.257	0.291
Adoni	Kurnool	0.136	0.185	0.210	0.245	0.277
Proddatur	Cuddapah	0.134	0.183	0.207	0.242	0.273
Chittor	Chittor	0.133	0.182	0.206	0.240	0.272
Ongole	Prakasam	0.128	0.175	0.198	0.231	0.261
Bheemavaram	West Godavari	0.125	0.171	0.194	0.226	0.256
Nandyal	Kurnool	0.120	0.164	0.186	0.217	0.245
Mehbubnagar	Mehbubnagar	0.117	0.159	0.180	0.211	0.238
Guntakul	Anantapur	0.108	0.147	0.166	0.194	0.219
Hindupur	Anantapur	0.105	0.143	0.162	0.189	0.213
Kothagudem	Khammam	0.102	0.139	0.158	0.184	0.208

The growth rates of urban population in India as projected by Prof. Ashish Bose is as follows:

Period	*Growth Rate (%)*
1991-2001	3.16
2001 2011	3.15
2011 2021	3.1

Annexure 4.1 Landed cost of imported coal

Landed cost of imported coal at Kakinada for cif @ $34/T

Element	Unit	Value
Cif	$/t	34
Cif @ Rs 46.36 per US dollar	Rs/t	1576
Basic customs @ 15% of cif	Rs/t	236
Surcharge @ 1.5% of cif	Rs/t	24
Spl Add Customs Duty @ 4%	Rs/t	73
Port Storage & handling	Rs/t	400
Landed cost	Rs/t	2310

Landed cost of imported coal at Kakinada for cif @ $40/T

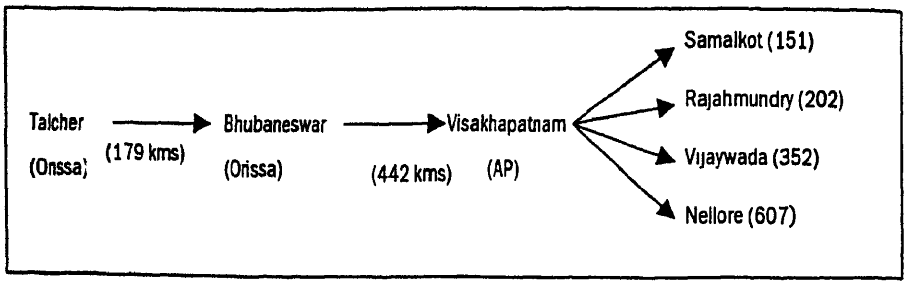
Element	Unit	Value
Cif	$/t	40
Cif @ Rs 46.36 per US dollar	Rs/t	1854
Basic customs @ 15% of cif	Rs/t	278
Surcharge @ 1.5% of cif	Rs/t	28
Spl Add Customs Duty @ 4%	Rs/t	86
Port Storage & handling	Rs/t	400
Landed cost	Rs/t	2647

Annexure 4.2 Delivered prices of coal to power plants

Delivered prices of imported coal

Location	Distance from Kakinada (kms)	Freight (Rs/T)	Delivered prices (Rs/T) (imported coal at cif $34)	Delivered prices (Rs/T) (imported coal at cif $40)
Samalkot	16	102	2412	2749
Rajahmundry	35	102	2412	2749
Vijaywada	185	159	2469	2806
Nellore	440	338	2648	2985

Rail route for supply of domestic coal from Talcher to power plants



Delivered prices of domestic coal at economic prices: ex-Talcher

Station	Rail Distance from Talcher (kms)	Freight (Rs/T)	Ex-Talcher Prices (Rs/T)	Delivered Prices (Rs/T)
Samalkot	772	583	617.24	1200.54
Rajahmundry	823	617	617.24	1234.34
Vijaywada	972	729	617.24	1346.64
Nellore	1228	921	617.24	1538.24

Annexure 4.3 Imputed values of gas for power generation at Samalkot

Element	Unit	Gas CCGT	Domestic coal		Imported Coal			
			Heat rate. 2500 Kcal/kWh	Heat rate: 2450 Kcal/kWh	Heat rate: 2500 Kcal/kWh		Heat rate: 2450 Kcal/kWh	
			Economic prices	Economic prices	$34/MT	$40/MT	$34/MT	$40/MT
Capital cost	Rs.million/MW	32.00	40.00	40.00	44 00	44 00	44.00	44.00
PLF		75%	75%	75%	75%	75%	75%	75%
Annual output (gross)	MWh	6570	6570	6570	6570	6570	6570	6570
Auxiliary consumption	(%)	3.0%	9.5%	9.5%	7 5%	7.5%	7.5%	7.5%
Units sent out/annum (net)	MWh	6373	5946	5946	6077	6077	6077	6077
Phasing of investment								
Year -3		0	0.2	0.2	0.2	0.2	0.2	0.2
Year -2		0.2	0.3	0.3	0.3	0.3	0.3	0.3
Year -1		0 5	0.4	0.4	0.4	0.4	0.4	0.4
Year -0		0.3	0.1	0.1	0.1	0.1	0.1	0.1
Total		1	1	1	1	1	1	1
Discount factor		0.12	0.12	0.12	0.12	0.12	0.12	0.12
NPV factor		1.18	1.28	1.28	1.28	1.28	1.28	1.28
Capital cost (incld IDC)	Rs.million/MW	37.62	51.02	51.02	56.13	56.13	56.13	56.13
Life of plant	Years	20.00	35.00	35.00	35.00	35.00	35.00	35.00
CRF		0.13	0.12	0.12	0.12	0.12	0.12	0.12
Annuitised capital cost	Rs.million/MW	5.04	6.24	6.24	6.87	6.87	6.87	6.87
Capital cost/kWh of power	Rs./kWh	0.79	1.05	1.05	1.13	1.13	1.13	1.13
Heat rate per unit sent out	kcal/kWh	1709	2762	2707	2703	2703	2649	2649
Heat rate per unit sent out	Btu/kWh	6782	10961	10742	10724	10724	10510	10510
Fuel consumption/kWh sent out	NM^3, kg/kWh	0.20	0.69	0.68	0.42	0.42	0.41	0.41
Fuel cost	Rs/t		1201	1201	2412	2749	2412	2749
Fuel calorific value	kcal/NM^3, kcal/kg	8500	4000	4000	6400	6400	6400	6400
Fuel cost/kWh sent out	Rs/kWh		0.83	0.81	1.02	1.16	1.00	1.14
Fixed operating cost as % of capital cost	(%)	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Total fixed operating cost	Rs. million	0.800	1.000	1.000	1.100	1.100	1.100	1.100
Fixed operating cost/ kWh sent out	Rs/kWh	0.126	0.168	0.168	0.181	0.181	0.181	0.181
Capital+Fixed O&M cost/kWh sent out	Rs/kWh	0.916	1.218	1.218	1.311	1.311	1.311	1.311
Total cost per kWh sent out	Rs/kWh		2.05	2.03	2.33	2.47	2.31	2.45
Total cost per kWh sent out	$/kWh		0.044	0.044	0.050	0.053	0.050	0.053
Imputed fuel charge	Rs/kWh		1.131	1.114	1.413	1.556	1.393	1.532
Imputed fuel charge	$/kWh		0.024	0.024	0.030	0.034	0.030	0.033
Imputed value for gas	$/MMBtu		3.60	3.54	4.49	4.95	4.43	4.87

Annexure 4.4 Imputed values of gas for power generation at Rajahmundry

Element	Unit	Gas CCGT	Domestic coal		Imported Coal		
			Heat rate: 2500 Kcal/kWh	Heat rate: 2450 Kcal/kWh	Heat rate: 2500 Kcal/kWh		Heat rate: 2450 Kcal/kWh
			Economic prices	Economic prices	$34/MT	$40/MT	$34/MT
Capital cost	Rs.million/MW	32.00	40.00	40.00	44.00	44.00	44.00
PLF		75%	75%	75%	75%	75%	75%
Annual output (gross)	MWh	6570	6570	6570	6570	6570	6570
Auxiliary consumption	(%)	3.0%	9.5%	9.5%	7.5%	7.5%	7.5%
Units sent out/annum (net)	MWh	6373	5946	5946	6077	6077	6077
Phasing of investment							
Year -3		0	0.2	0.2	0.2	0.2	0.2
Year -2		0.2	0.3	0.3	0.3	0.3	0.3
Year -1		0.5	0.4	0.4	0.4	0.4	0.4
Year -0		0.3	0.1	0.1	0.1	0.1	0.1
Total		1	1	1	1	1	1
Discount factor		0.12	0.12	0.12	0.12	0.12	0.12
NPV factor		1.18	1.28	1.28	1.28	1.28	1.28
Capital cost (incld IDC)	Rs.million/MW	37.62	51.02	51.02	56.13	56.13	56.13
Life of plant	Years	20.00	35.00	35.00	35.00	35.00	35.00
CRF		0.13	0.12	0.12	0.12	0.12	0.12
Annuitised capital cost	Rs.million/MW	5.04	6.24	6.24	6.87	6.87	6.87
Capital cost/kWh of power	Rs./kWh	0.79	1.05	1.05	1.13	1.13	1.13
Heat rate per unit sent out	kcal/kWh	1709	2762	2707	2703	2703	2649
Heat rate per unit sent out	Btu/kWh	6782	10961	10742	10724	10724	10510
Fuel consumption/kWh sent out	NM^3, kg/kWh	0.20	0.69	0.68	0.42	0.42	0.41
Fuel cost	Rs/t		1234	1234	2412	2749	2412
Fuel calorific value	kcal/NM^3, kcal/kg	8500	4000	4000	6400	6400	6400
Fuel cost/kWh sent out	Rs/kWh		0.85	0.84	1.02	1.16	1.00
Fixed operating cost as % of capital cost	(%)	0.025	0.025	0.025	0.025	0.025	0.025
Total fixed operating cost	Rs. million	0.800	1.000	1.000	1.100	1.100	1.100
Fixed operating cost/kWh sent out	Rs/kWh	0.126	0.168	0.168	0.181	0.181	0.181
Capital+Fixed O&M cost/kWh sent out	Rs/kWh	0.916	1.218	1.218	1.311	1.311	1.311
Total cost per kWh sent out	Rs/kWh		2.07	2.05	2.33	2.47	2.31
Total cost per kWh sent out	$/kWh		0.045	0.044	0.050	0.053	0.050
Imputed fuel charge	Rs/kWh		1.154	1.137	1.413	1.556	1.393
Imputed fuel charge	$/kWh		0.025	0.025	0.030	0.034	0.030
Imputed value for gas	$/MMBtu		3.67	3.62	4.49	4.95	4.43

Annexure 4.5 Imputed values for power generation at Vijaywada

Element	*Unit*	*Gas CCGT*	*Domestic coal*		*Imported Coal*			
			Heat rate: 2500 Kcal/kWh	Heat rate 2450 Kcal/kWh	Heat rate 2500 Kcal/kWh		Heat rate 2450 Kcal/kWh	
			Economic prices	Economic prices	$34/MT	$40/MT	$34/MT	$40/MT
Capital cost	Rs.million/MW	32.00	40.00	40.00	44.00	44.00	44.00	44.00
PLF		75%	75%	75%	75%	75%	75%	75%
Annual output (gross)	MWh	6570	6570	6570	6570	6570	6570	6570
Auxiliary consumption	(%)	3.0%	9.5%	9.5%	7.5%	7.5%	7.5%	7.5%
Units sent out/annum (net)	MWh	6373	5946	5946	6077	6077	6077	6077
Phasing of investment								
Year -3		0	0.2	0.2	0.2	0.2	0.2	0.2
Year -2		0.2	0.3	0.3	0.3	0.3	0.3	0.3
Year -1		0.5	0.4	0.4	0.4	0.4	0.4	0.4
Year -0		0.3	0.1	0.1	0.1	0.1	0.1	0.1
Total		1	1	1	1	1	1	1
Discount factor		0.12	0.12	0.12	0.12	0.12	0.12	0.12
NPV factor		1.18	1.28	1.28	1.28	1.28	1.28	1.28
Capital cost (incld IDC)	Rs.million/MW	37.62	51.02	51.02	56.13	56.13	56.13	56.13
Life of plant	Years	20.00	35.00	35.00	35.00	35.00	35.00	35.00
CRF		0.13	0.12	0.12	0.12	0.12	0.12	0.12
Annuitised capital cost	Rs.million/MW	5.04	6.24	6.24	6.87	6.87	6.87	6.87
Capital cost/kWh of power	Rs./kWh	0.79	1.05	1.05	1.13	1.13	1.13	1.13
Heat rate per unit sent out	kcal/kWh	1709	2762	2707	2703	2703	2649	2649
Heat rate per unit sent out	Btu/kWh	6782	10961	10742	10724	10724	10510	10510
Fuel consumption/kWh sent out	NM^3, kg/kWh	0.20	0.69	0.68	0.42	0.42	0.41	0.41
Fuel cost	Rs/t		1347	1347	2469	2806	2469	2806
Fuel calorific value	kcal/NM^3, kcal/kg	8500	4000	4000	6400	6400	6400	6400
Fuel cost/kWh sent out	Rs/kWh		0.93	0.91	1.04	1.18	1.02	1.16
Fixed operating cost as % of capital cost	(%)	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Total fixed operating cost	Rs. million	0.800	1.000	1.000	1.100	1.100	1.100	1.100
Fixed operating cost/kWh sent out	Rs/kWh	0.126	0.168	0.168	0.181	0.181	0.181	0.181
Capital+Fixed O&M cost/kWh sent out	Rs/kWh	0.916	1.218	1.218	1.311	1.311	1.311	1.311
Total cost per kWh sent out	Rs/kWh		2.15	2.13	2.35	2.50	2.33	2.47
Total cost per kWh sent out	$/kWh		0.046	0.046	0.051	0.054	0.050	0.053
Imputed fuel charge	Rs/kWh		1.232	1.213	1.437	1.580	1.416	1.556
Imputed fuel charge	$/kWh		0.027	0.026	0.031	0.034	0.031	0.034
Imputed value for gas	$/MMBtu		3.92	3.86	4.57	5.02	4.50	4.95

Annexure 4.6 Imputed values for power generation at Nellore

Element	*Unit*	*Gas CCGT*	*Domestic coal*		*Imported Coal*			
			Heat rate: 2500 Kcal/kWh	Heat rate: 2450 Kcal/kWh	Heat rate: 2500 Kcal/kWh		Heat rate: 2450 Kcal/kWh	
			Economic prices	Economic prices	$34/MT	$40/MT	$34/MT	$40/MT
Capital cost	Rs.million/MW	32.00	40.00	40.00	44.00	44.00	44.00	44.0
PLF		75%	75%	75%	75%	75%	75%	75%
Annual output (gross)	MWh	6570	6570	6570	6570	6570	6570	65
Auxiliary consumption	(%)	3.0%	9.5%	9.5%	7.5%	7.5%	7.5%	7.5%
Units sent out/annum (net)	MWh	6373	5946	5946	6077	6077	6077	60
Phasing of investment								
Year -3		0	0.2	0.2	0.2	0.2	0.2	0.
Year -2		0.2	0.3	0.3	0.3	0.3	0.3	0.
Year -1		0.5	0.4	0.4	0.4	0.4	0.4	0.4
Year -0		0.3	0.1	0.1	0.1	0.1	0.1	0.1
Total		1	1	1	1	1	1	[illegible]
Discount factor		0.12	0.12	0.12	0.12	0.12	0.12	0.1
NPV factor		1.18	1.28	1.28	1.28	1.28	1.28	1.2
Capital cost (incld IDC)	Rs.million/MW	37.62	51.02	51.02	56.13	56.13	56.13	56.1
Life of plant	Years	20.00	35.00	35.00	35.00	35.00	35.00	35.0
CRF		0.13	0.12	0.12	0.12	0.12	0.12	0.1
Annuitised capital cost	Rs.million/MW	5.04	6.24	6.24	6.87	6.87	6.87	6.8
Capital cost/kWh of power	Rs /kWh	0.79	1.05	1.05	1.13	1.13	1.13	1.1
Heat rate per unit sent out	kcal/kWh	1709	2762	2707	2703	2703	2649	2649
Heat rate per unit sent out	Btu/kWh	6782	10961	10742	10724	10724	10510	105
Fuel consumption/kWh sent out	NM^3, kg/kWh	0.20	0.69	0.68	0.42	0.42	0.41	0.4
Fuel cost	Rs/t		1538	1538	2648	2985	2648	2985
Fuel calorific value	kcal/NM^3, kcal/kg	8500	4000	4000	6400	6400	6400	6400
Fuel cost/kWh sent out	Rs/kWh		1.06	1.04	1.12	1.26	1.10	1.24
Fixed operating cost as % of capital cost	(%)	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Total fixed operating cost	Rs. million	0.800	1.000	1.000	1.100	1.100	1.100	1.100
Fixed operating cost/kWh sent out	Rs/kWh	0.126	0.168	0.168	0.181	0.181	0.181	0.18
Capital+Fixed O&M cost/kWh sent out	Rs/kWh	0.916	1.218	1.218	1.311	1.311	1.311	1.31
Total cost per kWh sent out	Rs/kWh		2.28	2.26	2.43	2.57	2.41	2.5
Total cost per kWh sent out	$/KWh		0.049	0.049	0.052	0.055	0.052	0.05
Imputed fuel charge	Rs/kWh		1.364	1.343	1.513	1.655	1.491	1.63
Imputed fuel charge	$/kWh		0.029	0.029	0.033	0.036	0.032	0.03
Imputed value for gas	$/MMBtu		4.34	4.27	4.81	5.26	4.74	5.1

Annexure 4.7 Imputed values of gas for urea production against urea imports at cif $ 150/MT

Element	*Unit*	*Value* new plants	*Value* expansion plans
Urea Capacity	Tons/Year	726000	726000
Capital Cost of gas based plant	Rs Million	17000	15000
Phasing of investment			
Year-2		0.2	0.2
Year-1		0.5	0.5
Year-0		0.3	0.3
Total		1	1
Discount factor		0.12	0.12
NPV factor		1.18	1.18
Capital cost (incld IDC)	Rs.million	19986	17635
Life of plant	Years	15	15
CRF		0.15	0.15
Annutised capital cost	Rs.million	2934	2589
Capital cost/Ton of urea	Rs./Ton	4042	3566
Gas calorific value	kcal/NM^3	8500	8500
Energy required per ton of urea	Gcal/Ton	5.40	5.40
Gas consumption/Ton of Urea	NM^3/Ton	635	635
Fixed operating cost/Ton of urea	Rs/T	854	854
Capital cost+Fixed O&M cost of gas based plant	Rs/T	4896	4420
Import Parity Price for urea at Kakinada			
Kakinada is the landing port			
cif price of urea	$/MT	150	150
Delivered prices	Rs/MT	6954	6954
Imputed value of gas	Rs/MT	2058	2534
Imputed value for gas	$/MMBtu	2.07	2.55
Import Parity Price for urea at Nellore			
Kakinada is the landing port			
Rail distance from Kakinada port	kms	440	440
Freight from Samalkot	Rs/T	329	329
cif price of urea	$/MT	150	150
Delivered prices	Rs/T	7283	7283
Imputed value of gas	Rs/T	2387	2863
Imputed value for gas	$/MMBtu	2.40	2.88
Import Parity Price for urea at Visakhapatnam			
Visakhapatnam is the landing port			
cif price of urea	$/MT	150	150
Delivered prices	Rs/T	6954	6954
Imputed value of gas	Rs/T	2058	2534
Imputed value for gas	$/MMBtu	2.07	2.55

Annexure 4.8 *Maximum price payable for gas if urea producer receives Rs. 9,000/MT*

Element	*Unit*	*Gas based urea plant* (new)	*Gas based urea plant* (expansion)
Urea Capacity	Tons/Year	726000	726000
Capital Cost (new plants)	Rs Million	17000	15000
Phasing of investment			
Year-2		0.2	0.2
Year-1		0.5	0.5
Year-0		0.3	0.3
Total		1	1
Discount factor		0.12	0.12
NPV factor		1.18	1.18
Capital cost (incld IDC)	Rs.million	19986	17635
Life of plant	Years	15	15
CRF		0.15	0.15
Annutised capital cost	Rs.million	2934	2589
Capital cost/Ton of urea	Rs./Ton	4042	3566
Fuel calorific value	kcal/NM^3	8500	8500
Energy required per ton of urea	Gcal/Ton	5.40	5.40
Fuel consumption/Ton of Urea	NM^3/Ton	635	635
Fixed operating cost	Rs/Ton	854	854
Capital+Fixed O&M cost/Ton of Urea	Rs/Ton	4896	4420
Price of urea received by producer	Rs/T	8600	8600
Maximum price payable for gas/Ton of urea	Rs/T	3704	4180
Maximum price payable for gas/Ton of urea	$/T	79.9	90.2
Maximum price payable for gas	**$/MMBtu**	**3.73**	**4.21**

Annexure 4.9 Landed cost of Fuel Oil

Fob of FO correspond to Fob - Duabi for Crude oil @ $16/bbl		
Parameters	*Unit*	*Value*
FOB price at Persian Gulf	$/MT	83
Dollar conversion rate	Rs/$	46.36
FOB Price	Rs/MT	3847.88
Load Port Charges @ $ 1/MT	Rs/MT	46.36
Ocean Freight @ $ 15/MT	Rs/MT	695.40
C&F Cost	Rs/MT	4589.64
Insurance @ 0.3% of C&F	Rs/MT	13.77
Ocean Loss @ 0.3% of C&F	Rs/MT	13.77
CIF Cost	Rs/MT	4617.18
Landing Charges (LANC) @ 1% of CIF	Rs/MT	46.17
LC Charges @ 0.6% of CIF Cost	Rs/MT	27.70
CIF + LC + LANC	Rs/MT	4691.05
Basic Customs Duty @ 10%	Rs/MT	469.11
CIF + LC + LANC + Customs	Rs/MT	5160.16
Countervailing Duty (CVD) @ 15%	Rs/MT	774.02
Total Cost	Rs/MT	5934.18
Port Dues, Wharfage, Demurrage	Rs/MT	100.00
Landed Cost	Rs/MT	6034.18

Fob of FO correspond to Fob - Duabi for Crude oil @ $20/bbl		
Parameters	*Unit*	*Value*
FOB price at Persian Gulf	$/MT	108
Dollar conversion rate	Rs/$	46.36
FOB Price	Rs/MT	5006.88
Load Port Charges @ $ 1/MT	Rs/MT	46.36
Ocean Freight @ $ 15/MT	Rs/MT	695.4
C&F Cost	Rs/MT	5748.64
Insurance @ 0.3% of C&F	Rs/MT	17.24592
Ocean Loss @ 0.3% of C&F	Rs/MT	17.24592
CIF Cost	Rs/MT	5783.13
Landing Charges (LANC) @ 1% of CIF	Rs/MT	57.83
LC Charges @ 0.6% of CIF Cost	Rs/MT	34.70
CIF + LC + LANC	Rs/MT	5875.66
Basic Customs Duty @ 10%	Rs/MT	587.57
CIF + LC + LANC + Customs	Rs/MT	6463.23
Countervailing Duty (CVD) @ 15%	Rs/MT	969.48
Total Cost	Rs/MT	7432.71
Port Dues, Wharfage, Demurrage	Rs/MT	100
Landed Cost	Rs/MT	7532.71

Fob of FO correspond to Fob - Duabi for Crude oil @ $25/bbl		
Parameters	***Unit***	***Value***
FOB price at Persian Gulf	$/MT	139
Dollar conversion rate	Rs/$	46.36
FOB Price	Rs/MT	6444.04
Load Port Charges @ $ 1/MT	Rs/MT	46.36
Ocean Freight @ $ 15/MT	Rs/MT	695.4
C&F Cost	Rs/MT	7185.8
Insurance @ 0.3% of C&F	Rs/MT	21.5574
Ocean Loss @ 0.3% of C&F	Rs/MT	21.5574
CIF Cost	Rs/MT	7228.91
Landing Charges (LANC) @ 1% of CIF	Rs/MT	72.29
LC Charges @ 0.6% of CIF Cost	Rs/MT	43.37
CIF + LC + LANC	Rs/MT	7344.58
Basic Customs Duty @ 10%	Rs/MT	734.46
CIF + LC + LANC + Customs	Rs/MT	8079.04
Countervailing Duty (CVD) @ 15%	Rs/MT	1211.86
Total Cost	Rs/MT	9290.89
Port Dues, Wharfage, Demurrage	Rs/MT	100
Landed Cost	Rs/MT	9390.89

Annexure 4.10 Landed cost of Liquefied Petroleum Gas

Fob of LPG correspond to Fob - Duabi for Crude oil @ $16/bbl		
Parameters	*Unit*	*Value*
FOB price at Persian Gulf	$/MT	186.47
Dollar conversion rate	Rs/$	46.36
FOB Price	Rs/MT	8644.94
Load Port Charges @ $ 1/MT	Rs/MT	46.36
Ocean Freight @ $ 35/MT	Rs/MT	1622.60
C&F Cost	Rs/MT	10313.90
Insurance @ 0.5% of C&F	Rs/MT	51.57
CIF Cost	Rs/MT	10365.47
Landing Charges (LANC) @ 1% of CIF	Rs/MT	103.65
LC Charges @ 0.6% of CIF Cost	Rs/MT	62.19
CIF + LC + LANC	Rs/MT	10531.32
Basic Customs Duty @ 10%	Rs/MT	1053.13
CIF + LC + LANC + Customs	Rs/MT	11584.45
Countervailing Duty (CVD) @ 10%	Rs/MT	1158.45
Total Cost	Rs/MT	12742.90
Port Dues, Wharfage, Demurrage	Rs/MT	100
Landed Cost	Rs/MT	12842.90

Fob of LPG correspond to Fob - Duabi for Crude oil @ $20/bbl		
Parameters	*Unit*	*Value*
FOB price at Persian Gulf	$/MT	233
Dollar conversion rate	Rs/$	46.36
FOB Price	Rs/MT	10801.88
Load Port Charges @ $ 1/MT	Rs/MT	46.36
Ocean Freight @ $ 35/MT	Rs/MT	1622.6
C&F Cost	Rs/MT	12470.84
Insurance @ 0.5% of C&F	Rs/MT	62.3542
CIF Cost	Rs/MT	12533.19
Landing Charges (LANC) @ 1% of CIF	Rs/MT	125.33
LC Charges @ 0.6% of CIF Cost	Rs/MT	75.20
CIF + LC + LANC	Rs/MT	12733.73
Basic Customs Duty @ 10%	Rs/MT	1273.37
CIF + LC + LANC + Customs	Rs/MT	14007.10
Countervailing Duty (CVD) @ 10%	Rs/MT	1400.71
Total Cost	Rs/MT	15407.81
Port Dues, Wharfage, Demurrage	Rs/MT	100
Landed Cost	Rs/MT	15507.81

Fob of LPG correspond to Fob - Duabi for Crude oil @ $25/bbl		
Parameters	*Unit*	*Value*
FOB price at Persian Gulf	$/MT	291
Dollar conversion rate	Rs/$	46.36
FOB Price	Rs/MT	13490.76
Load Port Charges @ $ 1/MT	Rs/MT	46.36
Ocean Freight @ $ 35/MT	Rs/MT	1622.6
C&F Cost	Rs/MT	15159.72
Insurance @ 0.5% of C&F	Rs/MT	75.7986
CIF Cost	Rs/MT	15235.52
Landing Charges (LANC) @ 1% of CIF	Rs/MT	152.36
LC Charges @ 0.6% of CIF Cost	Rs/MT	91.41
CIF + LC + LANC	Rs/MT	15479.29
Basic Customs Duty @ 10%	Rs/MT	1547.93
CIF + LC + LANC + Customs	Rs/MT	17027.22
Countervailing Duty (CVD) @ 10%	Rs/MT	1702.72
Total Cost	Rs/MT	18729.94
Port Dues, Wharfage, Demurrage	Rs/MT	100
Landed Cost	Rs/MT	18829.94

Annexure 4.11 Delivered costs of Fuel Oil,Liquefied Petroleum Gas and domestic coal for industries

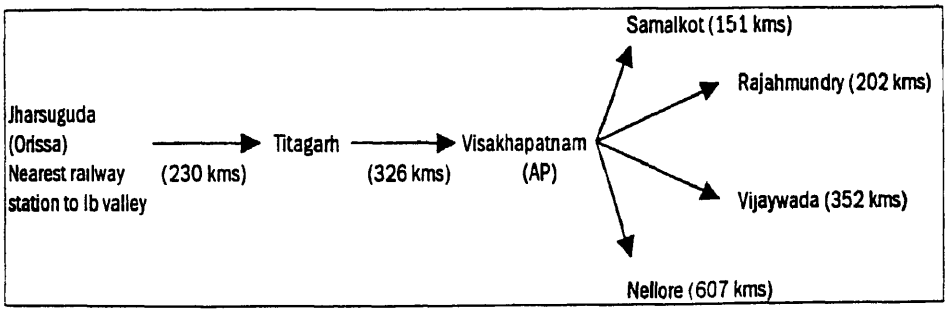
Delivered prices of Fuel Oil

Station	Distance from Visakhapatnam (kms)	Freight for FO (Rs/MT)	Delivered prices of FO (Rs/MT)		
			Crude prices $16/bbl	Crude prices $20/bbl	Crude prices $25/bbl
Visakhapatnam	0	0	6034.18	7532.71	9390.89
Samalkot	151	309	6343.18	7841.71	9699.89
Rajahmundry	202	389.3	6423.48	7922.01	9780.19
Vijaywada	352	643.4	6677.58	8176.11	10034.29
Nellore	607	1093.5	7127.68	8626.21	10484.39
Hyderabad	712	1278	7312.18	8810.71	10668.89

Delivered prices of Liquefied Petroleum Gas

Station	Diatance from Visakhapatnam (kms)	Freight for LPG (Rs/T)	Delivered prices of LPG (Rs/MT)		
			Crude prices $16/bbl	Crude prices $20/bbl	Crude prices $25/bbl
Visakhapatnam	0	0	12842.8959	15507.80762	18829.93715
Samalkot	151	273.2	13116.0959	15781.00762	19103.13715
Rajahmundry	202	343.4	13186.2959	15851.20762	19173.33715
Vijaywada	351	565.7	13408.5959	16073.50762	19395.63715
Nellore	607	959.2	13802.0959	16467.00762	19789.13715
Hyderabad	712	1121.5	13964.3959	16629.30762	19951.43715

Rail route for supply of coal from Ib valley



Delivered prices of domestic coal from Ib valley

Station	Rail Distance from Jharsuguda (kms)	Freight (Rs/MT)	Ex-Ib prices (Rs/MT)	Delivered prices (Rs/MT)
Visakhapatnam	556	422.8	1008.29	1431.09
Samalkot	707	530	1008.29	1538.29
Rajahmundry	758	568	1008.29	1576.29
Vijaywada	908	691.5	1008.29	1699.79
Nellore	1163	864.6	1008.29	1872.89
Hyderabad	1268	939	1008.29	1947.29

Annexure 4.12 Imputed values of gas in industries and city distribution against LPG

At Visakhapatnam

Element	*Unit*	*Value*
Imported LPG price (1)	Rs /Ton	12842.90
Imported LPG price (2)	Rs /Ton	15507.81
Imported LPG price (3)	Rs /Ton	18829.94
Calorific Value: LPG	Kcal/Kg	11300
LPG price (1)	Rs/Kcal	0.0011
LPG price (2)	Rs/Kcal	0.0014
LPG price (3)	Rs/Kcal	0.0017
Calorific Value: LNG	Kcal/m3	8500
Equivalent gas price (1)	Rs/m3	9.66
Equivalent gas price (2)	Rs/m3	11.67
Equivalent gas price (3)	Rs/m3	14.16
Imputed value (1)	$/MMBtu	6.18
Imputed value (2)	$/MMBtu	7.46
Imputed value (3)	$/MMBtu	9.06

At Samalkot

Element	*Unit*	*Value*
Imported LPG price (1)	Rs /Ton	13116.10
Imported LPG price (2)	Rs /Ton	15781.01
Imported LPG price (3)	Rs /Ton	19103.14
Calorific Value: LPG	Kcal/Kg	11300
LPG price (1)	Rs/Kcal	0.0012
LPG price (2)	Rs/Kcal	0.0014
LPG price (3)	Rs/Kcal	0.0017
Calorific Value: LNG	Kcal/m3	8500
Equivalent gas price (1)	Rs/m3	9.87
Equivalent gas price (2)	Rs/m3	11.87
Equivalent gas price (3)	Rs/m3	14.37
Imputed value (1)	$/MMBtu	6.31
Imputed value (2)	$/MMBtu	7.59
Imputed value (3)	$/MMBtu	9.19

At Rajahmundry

Element	*Unit*	*Value*
Imported LPG price (1)	Rs /Ton	13186.30
Imported LPG price (2)	Rs /Ton	15851.21
Imported LPG price (3)	Rs /Ton	19173.34
Calorific Value: LPG	Kcal/Kg	11300
LPG price (1)	Rs/Kcal	0.0012
LPG price (2)	Rs/Kcal	0.0014
LPG price (3)	Rs/Kcal	0.0017
Calorific Value LNG	Kcal/m3	8500
Equivalent gas price (1)	Rs/m3	9.92
Equivalent gas price (2)	Rs/m3	11.92
Equivalent gas price (3)	Rs/m3	14.42
Imputed value (1)	$/MMBtu	6.34
Imputed value (2)	$/MMBtu	7.62
Imputed value (3)	$/MMBtu	9.22

At Vijaywada

Element	*Unit*	*Value*
Imported LPG price (1)	Rs /Ton	13408.60
Imported LPG price (2)	Rs /Ton	16073.51
Imported LPG price (3)	Rs /Ton	19395.64
Calorific Value: LPG	Kcal/Kg	11300
LPG price (1)	Rs/Kcal	0.0012
LPG price (2)	Rs/Kcal	0.0014
LPG price (3)	Rs/Kcal	0.0017
Calorific Value: LNG	Kcal/m3	8500
Equivalent gas price (1)	Rs/m3	10.09
Equivalent gas price (2)	Rs/m3	12.09
Equivalent gas price (3)	Rs/m3	14.59
Imputed value (1)	**$/MMBtu**	**6.45**
Imputed value (2)	**$/MMBtu**	**7.73**
Imputed value (3)	**$/MMBtu**	**9.33**

At Nellore

Element	*Unit*	*Value*
Imported LPG price (1)	Rs /Ton	13802.10
Imported LPG price (2)	Rs /Ton	16467.01
Imported LPG price (3)	Rs /Ton	19789.14
Calorific Value: LPG	Kcal/Kg	11300
LPG price (1)	Rs/Kcal	0.0012
LPG price (2)	Rs/Kcal	0.0015
LPG price (3)	Rs/Kcal	0.0018
Calorific Value: LNG	Kcal/m3	8500
Equivalent gas price (1)	Rs/m3	10.38
Equivalent gas price (2)	Rs/m3	12.39
Equivalent gas price (3)	Rs/m3	14.89
Imputed value (1)	**$/MMBtu**	**6.64**
Imputed value (2)	**$/MMBtu**	**7.92**
Imputed value (3)	**$/MMBtu**	**9.52**

At Hyderabad

Element	*Unit*	*Value*
Imported LPG price (1)	Rs /Ton	13964.40
Imported LPG price (2)	Rs /Ton	16629.31
Imported LPG price (3)	Rs /Ton	19951.44
Calorific Value: LPG	Kcal/Kg	11300
LPG price (1)	Rs/Kcal	0.0012
LPG price (2)	Rs/Kcal	0.0015
LPG price (3)	Rs/Kcal	0.0018
Calorific Value: LNG	Kcal/m3	8500
Equivalent gas price (1)	Rs/m3	10.50
Equivalent gas price (2)	Rs/m3	12.51
Equivalent gas price (3)	Rs/m3	15.01
Imputed value (1)	**$/MMBtu**	**6.72**
Imputed value (2)	**$/MMBtu**	**8.00**
Imputed value (3)	**$/MMBtu**	**9.60**

LPG Price (1): **Fob of LPG correspond to Fob - Duabi for Crude oil @ $16/bbl**
LPG Price (2): **Fob of LPG correspond to Fob - Duabi for Crude oil @ $20/bbl**
LPG Price (3): **Fob of LPG correspond to Fob - Duabi for Crude oil @ $25/bbl**

Annexure 4.13 Imputed values of gas in industries and city distribution against FO

At Visakhapatnam

Element	*Unit*	*Value*
FO price (1)	Rs /Ton	6034
FO price (2)	Rs /Ton	7533
FO price (3)	Rs /Ton	9391
Calorific Value: FO	Kcal/Kg	10440
FO price (1)	Rs/Kcal	0.0006
FO price (2)	Rs/Kcal	0.0008
FO price (3)	Rs/Kcal	0.0010
Calorific Value:LNG	Kcal/m3	8500
Equivalent gas price (1)	Rs/m3	5.21
Equivalent gas price (2)	Rs/m3	6.50
Equivalent gas price (3)	Rs/m3	8.10
Imputed value (1)	**$/MMBtu**	3.14
Imputed value (2)	**$/MMBtu**	3.92
Imputed value (3)	**$/MMBtu**	4.89

At Samalkot

Element	*Unit*	*Value*
FO price (1)	Rs /Ton	6343
FO price (2)	Rs /Ton	7842
FO price (3)	Rs /Ton	9700
Calorific Value: FO	Kcal/Kg	10440
FO price (1)	Rs/Kcal	0.0006
FO price (2)	Rs/Kcal	0.0008
FO price (3)	Rs/Kcal	0.0010
Calorific Value:LNG	Kcal/m3	8500
Equivalent gas price (1)	Rs/m3	5.47
Equivalent gas pnce (2)	Rs/m3	6.77
Equivalent gas pnce (3)	Rs/m3	8.37
Imputed value (1)	**$/MMBtu**	3.30
Imputed value (2)	**$/MMBtu**	4.08
Imputed value (3)	**$/MMBtu**	5.05

At Rajahmundry

Element	*Unit*	*Value*
FO pnce (1)	Rs /Ton	6423
FO price (2)	Rs /Ton	7922
FO price (3)	Rs /Ton	9780
Calorific Value: FO	Kcal/Kg	9850
FO pnce (1)	Rs/Kcal	0.0007
FO pnce (2)	Rs/Kcal	0.0008
FO pnce (3)	Rs/Kcal	0.0010
Calorific Value.LNG	Kcal/m3	8500
Equivalent gas pnce (1)	Rs/m3	5.54
Equivalent gas pnce (2)	Rs/m3	6.84
Equivalent gas pnce (3)	Rs/m3	8.44
Imputed value (1)	**$/MMBtu**	3.34
Imputed value (2)	**$/MMBtu**	4.12
Imputed value (3)	**$/MMBtu**	5.09

At Vijaywada

Element	Unit	Value
FO price (1)	Rs /Ton	6678
FO price (2)	Rs /Ton	8176
FO price (3)	Rs /Ton	10034
Calorific Value: FO	Kcal/Kg	9850
FO price (1)	Rs/Kcal	0.0007
FO price (2)	Rs/Kcal	0.0008
FO price (3)	Rs/Kcal	0.0010
Calorific Value:LNG	Kcal/m3	8500
Equivalent gas price (1)	Rs/m3	5.76
Equivalent gas price (2)	Rs/m3	7.06
Equivalent gas price (3)	Rs/m3	8.66
Imputed value (1)	$/MMBtu	3.48
Imputed value (2)	$/MMBtu	4.26
Imputed value (3)	$/MMBtu	5.22

At Nellore

Element	Unit	Value
FO price (1)	Rs /Ton	7128
FO price (2)	Rs /Ton	8626
FO price (3)	Rs /Ton	10484
Calorific Value: FO	Kcal/Kg	9850
FO price (1)	Rs/Kcal	0.0007
FO price (2)	Rs/Kcal	0.0009
FO price (3)	Rs/Kcal	0.0011
Calorific Value:LNG	Kcal/m3	8500
Equivalent gas price (1)	Rs/m3	6.15
Equivalent gas price (2)	Rs/m3	7.44
Equivalent gas price (3)	Rs/m3	9.05
Imputed value (1)	$/MMBtu	3.71
Imputed value (2)	$/MMBtu	4.49
Imputed value (3)	$/MMBtu	5.46

At Hyderabad

Element	Unit	Value
FO price (1)	Rs /Ton	7312
FO price (2)	Rs /Ton	8811
FO price (3)	Rs /Ton	10669
Calorific Value: FO	Kcal/Kg	9850
FO price (1)	Rs/Kcal	0.0007
FO price (2)	Rs/Kcal	0.0009
FO price (3)	Rs/Kcal	0.0011
Calorific Value:LNG	Kcal/m3	8500
Equivalent gas price (1)	Rs/m3	6.31
Equivalent gas price (2)	Rs/m3	7.60
Equivalent gas price (3)	Rs/m3	9.21
Imputed value (1)	$/MMBtu	3.81
Imputed value (2)	$/MMBtu	4.59
Imputed value (3)	$/MMBtu	5.55

FO Price (1): Fob of FO correspond to Fob - Duabi for Crude oil @ $16/bbl
FO Price (2): Fob of FO correspond to Fob - Duabi for Crude oil @ $20/bbl
FO Price (3): Fob of FO correspond to Fob - Duabi for Crude oil @ $25/bbl

Annexure 4.14 Imputed values of gas in industries and city distribution against domestic coal

Element	*Unit*	*Value*
Domestic coal price	Rs /Ton	1431.1
Calorific Value: Domestic coal	Kcal/Kg	4800
Coal price	Rs/Kcal	0.0003
Calorific Value:LNG	Kcal/m3	8500
Equivalent gas price	Rs/m3	2.53
Imputed value	$/MMBtu	1.62

Element	*Unit*	*Value*
Domestic coal price	Rs /Ton	1538.3
Calorific Value: Domestic coal	Kcal/Kg	4800
Coal price	Rs/Kcal	0.0003
Calorific Value:LNG	Kcal/m3	8500
Equivalent gas price	Rs/m3	2.72
Imputed value	$/MMBtu	1.74

Element	*Unit*	*Value*
Domestic coal price	Rs /Ton	1576.3
Calorific Value: Domestic coal	Kcal/Kg	4800
Coal price	Rs/Kcal	0.0003
Calorific Value:LNG	Kcal/m3	8500
Equivalent gas price	Rs/m3	2.79
Imputed value	$/MMBtu	1.79

Element	*Unit*	*Value*
Domestic coal price	Rs /Ton	1699.8
Calorific Value: Domestic coal	Kcal/Kg	4800
Coal price	Rs/Kcal	0.0004
Calorific Value:LNG	Kcal/m3	8500
Equivalent gas price	Rs/m3	3.01
Imputed value	$/MMBtu	1.92

Element	*Unit*	*Value*
Domestic coal price	Rs /Ton	1872.9
Calorific Value: Domestic coal	Kcal/Kg	4800
Coal price	Rs/Kcal	0.0004
Calorific Value:LNG	Kcal/m3	8500
Equivalent gas price	Rs/m3	3.32
Imputed value	$/MMBtu	2.12

Element	*Unit*	*Value*
Domestic coal price	Rs /Ton	1947.3
Calorific Value: Domestic coal	Kcal/Kg	4800
Coal price	Rs/Kcal	0.0004
Calorific Value:LNG	Kcal/m3	8500
Equivalent gas price	Rs/m3	3.45
Imputed value	$/MMBtu	2.21

Appendices

Appendix I: Terms of Reference

Scope of study

Scope

The study area covers the state of Andhra Pradesh. TERI would undertake the study in two phases. In the first phase, potential anchor load customers in the power and fertiliser sectors would be identified. TERI will interact with all potential anchor load customers to assess their individual requirements. Results of the field survey would be used to estimate the short-term demand for gas (by 2005). In addition, long-term estimates for gas demand (till 2015) from the power and fertiliser sectors would also be detailed.

In the second phase, TERI would undertake an in-depth analysis of gas demand in the vicinity of anchor load customers. Field surveys will be conducted to identify potential gas demand from industrial clusters and city distribution. Survey results would be distilled to provide short-term demand estimates. In addition, estimates of long-term gas demand for industrial use and city distribution would be also be provided.

Terms of Reference

The specific TORs for the study include:

1. Identification of existing consumers of natural gas with details of current consumption levels, fuel sources, etc. and their additional gas requirements based on proposed expansions/additions till the year 2005
2. Potential gas demand from existing consumers currently on alternative feedstock/fuels (coal, FO/LSHS, Naphtha) with details of current consumption levels, fuel sources, and their potential additional requirements based on proposed expansions/additions till the year 2005
3. Long term gas requirements for power generation, fertiliser production, industrial use and city distribution till the year 2015
4. Gas allocation and supplies by GAIL to current gas consumers, outline of the existing pipeline network and nature of gas sale contracts covering important features such as term, take-or-pay, flexibility etc.

5. Projections on natural gas availability from the currently known reserves in the Krishna-Godavari basin upto the year 2015, based on Plan/Government estimates, and an assessment of the on going exploration work in the area
6. Competitiveness of natural gas in user industries as compared to alternative feedstock and fuels (to be established at anchor load sites).

Deliverables

The proposed deliverables of the study are,

Phase I

1. Identification of existing consumers using gas for power generation and fertiliser production
2. Current gas allocation, actual supplies and nature of contracts with existing gas consumers
3. Short-term demand for gas for power generation and fertiliser production
4. Outline of GAIL's existing pipeline network
5. Projections on natural gas availability in the state upto the year 2015
6. Competitiveness of natural gas as compared to alternative feedstock and fuels

Phase II

1. Existing and potential industrial gas consumers in the vicinity of anchor load consumers
2. Short-term demand for gas for industrial use and city distribution
3. Long-term demand for gas for power generation, fertiliser production, industrial use and city distribution
4. Aggregate natural gas demand-supply analysis for the state of Andhra Pradesh

Deliverables and Methodology

Phase I

1. Identification of existing consumers using gas for power generation and fertiliser production
2. Current gas allocation, actual supplies and nature of contracts with existing gas consumers
3. Short-term demand for gas for power generation and fertiliser production

During the first phase of the project, TERI teams will interact with existing and potential gas consumers in the power and fertiliser sectors to identify the anchor loads. The primary survey would cover 100% of the existing and potential power (in excess of 50 MW) and fertiliser plants.

For existing gas consumers the survey results will incorporate details such as gas allocated, actual gas sales, nature of current contracts, etc. In addition information on proposed additions/expansions of existing units would also be solicited to estimate incremental gas demand from an existing consumer. Potential gas consumers would be contacted to ascertain current consumption levels of alternative fuel/feedstock, fuel supply arrangements, willingness to switch to natural gas, etc. Information on proposed expansions/additions to facilities of potential consumers would also be solicited to estimate the potential incremental gas demand.

4. Outline of GAIL's existing pipeline network

The current gas pipeline network in Andhra Pradesh will be provided, along with specifications such as length, diameter only. Other technical details such as gas pressure etc may not be easily available and will be provided only on a best endeavour basis.

5. Projections on natural gas availability in the state upto the year 2015

Official projections on gas availability from Krishna-Godavari and Rawa fields will be furnished. This data will be sourced from official publications, and will be undertaken on a best endeavour basis. In addition, TERI would also provide their assessment of the achievability of the above projections and their judgement of the actual gas availability year by year upto 2015. These scenarios will be used to develop sensitivities in the demand-supply analysis.
Proposed LNG terminals in the states of Andhra Pradesh, Orissa, and Tamil Nadu will also be discussed in the context of this project.

6. Competitiveness of natural gas as compared to alternative feedstock and fuels

Imputed fuel cost gives the maximum that can be charged for gas, while maintaining the cost of generation/production equal to that of the competing technologies/ fuels/feedstock, at a particular location.
Imputed values for gas will be established at select locations in the state (anchor load sites).

Phase II

1. Existing and potential industrial gas consumers in the vicinity of anchor load consumers
2. Short-term demand for gas for industrial use and city distribution

In the second phase, field surveys would be undertaken in the vicinity of anchor load customers identified in the first phase of the study. Again, both existing and potential customers would be contacted as detailed in the first phase methodology so as to ensure a coverage of major industrial consumers that would account for a substantial proportion of gas demand by the industries (excluding power and fertiliser).
Estimates of gas demand for city distribution would be based on likely levels of substitution of demand for Liquefied Petroleum Gas by piped gas supplies.

3. Long-term demand for gas for power generation, fertiliser production, industrial use and city distribution

Power generation
TERI will develop long-term estimates for power demand in the state of Andhra Pradesh. The long-term forecasts would be based on secondary sources of information. TERI will also undertake a critical review of the latest forecasts carried out by the Central Electricity Authority (CEA) under the 16th Electric Power Survey.

Power demand projections would be used to assess generation requirements. From these, generation that is likely to be met from the existing capacity in the state, sanctioned and on-going power projects, realistic planned expansion of modes of generation other than thermal, as also imports from other states in the southern grid, and other grids will be netted out. Next, relative fuel economics for alternative modes of generation would be assessed to identify the likely choices of thermal generation. Gas demand would be subsequently estimated on the basis of anticipated gas based power generation.

Fertiliser production

Natural gas is suitable for production of nitrogenous fertilisers only. TERI will develop long-term projections for the demand for nitrogenous fertilisers at both the national level and in the state of Andhra Pradesh. Fertiliser demand would be assessed on the basis of increase in gross cropped area and nutrient requirements per unit area under cultivation.

Domestic all India fertiliser production would be assessed in light of Government policy on food/fertiliser security. Assessments for likely production levels in Andhra Pradesh would be subsequently assessed to estimate gas demand for feedstock use.

Industrial use

Gas demand for industrial use in the long-term would be based on intensity of gas usage. Intensity refers to fuel consumption per unit of value added. TERI will develop long-term estimates of growth in value added in the state economy and project trends in intensity of gas usage till 2015. Gas demand for industrial use would be accordingly derived from the above mentioned.

City Distribution

Estimates of gas demand for city distribution would be based on likely levels of substitution of demand for Liquefied Petroleum Gas by piped gas supplies.

4. Aggregate natural gas demand-supply analysis for the state of Andhra Pradesh

The results of the first and second phases, will be pooled together to provide an aggregate gas demand supply balance in the state.

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Appendix 2: Presentation of Phase I

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A Study on Gas Demand in Andhra Pradesh

Presentation to : BP International Ltd

4th November, 2000

Power Sector

Reforms in the power sector

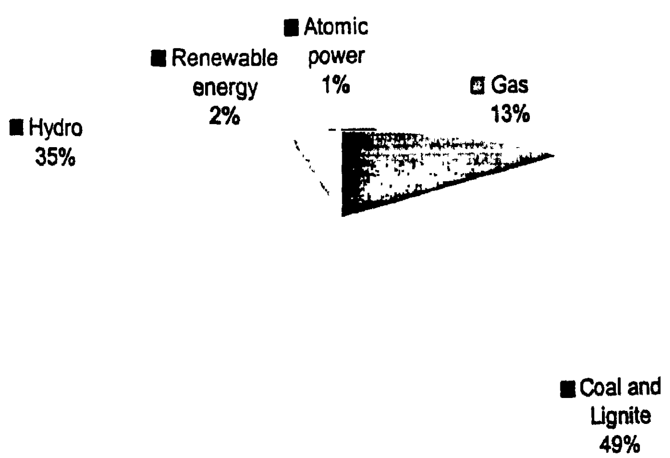
- Andhra Pradesh Electricity Reform Act 1998 → third state to undertake reforms
- APSEB split
  - Andhra Pradesh Power Generation Corporation (APGENCO)
  - Andhra Pradesh Transmission Corporation (APTRANSCO)
- Andhra Pradesh Electricity Regulatory Commission set up on 31.03.1999
- Four Distribution companies proposed

Installed capacity

Total installed Capacity 7856.62 MW

- APGENCO 5488.50 MW
- Joint & Central Sector 1352.50 MW
- Private sector 1015.62 MW

Fuel wise installed capacity



Power demand-supply (MW)

Element	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05
Peak demand	8275	8780	9297	9822	10378	10951
Required installed capacity	9305	9873	10715	11743	12335	12800
Existing capacity*	6962	7857	7857	7857	7857	7857
Captive capacity	1191	1191	1191	1191	1191	1191
Capacity shortfall	1152	825	1667	2695	3287	3752

** As on 31.3.2000 (except 1999-00)*

Power demand-supply (MW)

[redacted]

Element	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05
Peak demand	8901	9089	9384	9639	9915	10233
Required installed capacity	9708	10221	10816	11525	11785	11965
Existing capacity*	6962	7857	7857	7857	7857	7857
Captive generation	1191	1191	1191	1191	1191	1191
Capacity shortfall	1555	1173	1768	2477	2737	2917

** As on 31 3 2000 (except 1999-00)*

Likely capacity additions till 2005

Location	Promoter	Fuel Type	Capacity (MW)	Date Comm.
Under construction				
Srisailam LBPH	APGENCO	Hydro	900	2000-03
Peddapuram Samalkot	BSES	Naphtha	200	2001
LVS Power Project	LVS Power Ltd.	LSHS	36.8	2001
Simhadri	NTPC	Coal	1000	2002
Ramagundam-III	NTPC	Coal	234	2003
Talcher-II	NTPC	Coal	425	2004-06
Planned				
Jeggurupadu (expansion)	GVK	Gas	220	2004
Peddapuram	Gautam Power & NCC	Gas	477	2004
Vemagiri	Vemagiri	Gas	520	2004
Konaseema	Oakwell	Gas	360	2005
Ramagundam	BPL Power Projects	Coal	520	2005

Likely capacity addition: 2005-2015

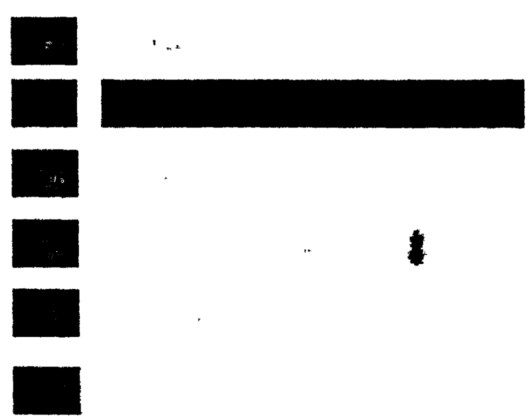
Location	Promoter	Fuel Type	Capacity (MW)	Date Comm.
Rayalsema – II	APGENCO	Coal	420	2006
Kakinada (expansion)	SPGL	Gas	360	2006
VTPS	APGENCO	Coal	660	2007
Krishnapatnam -A	GVK Industries	Coal (IMP)	520	2007
Jaurala	APGENCO	Hydro	110	2008
Vishakhapatnam	HPCL	Ref. Res.	585	2009
Vishakhapatnam	HNPCL	Coal	1040	Delayed
Krishnapatnam	M/S BBI Power	Coal (IMP)	520	Delayed

Demand-supply gap

Required capacity: 13351 MW
Likely capacity: 12749 MW
Capacity shortfall : 601 MW

Required capacity: 18174MW
Likely capacity: 15404 MW
Capacity shortfall : 2769 MW

Consumer Survey



GVK Industries

- **Location:** Jeggurupadu
- **Capacity:** 216 MW
- **Allocation:** 0.75 MMCMD
- **Deficit:** 0.342 MMCMD
- **Expansion Plans:**
  - Capacity Addition: 360 MW
  - Likely Date: 2003
  - Fuel Type: Gas
  - Allocation: 1.1 MMCMD
  - FSA Status: With GAIL

Spectrum Power Generation Ltd.

- **Location:** Kakinada
- **Capacity:** 207.88 MW
- **Allocation:** 0.75MMCMD
- **Deficit:** 0.25MMCMD
- **Expansion Plans:**
  - Capacity Addition: 360 MW
  - Likely Date: 2003
  - Fuel Type: Gas
  - Allocation: 0.75 MMCMD
  - FSA Status: With GAIL

LANCO

- **Location:** Kondapalli
- **Capacity:** 360 MW
- **Allocation:** 1.12 MMCMD
- **Deficit:** 0.367 MMCMD
- **Expansion Plans:**
  - Capacity Addition: 360 MW
  - Likely Date: 2003
  - Fuel Type: Gas
  - FSA Status: Not Yet

Gautami Power Limited

- **Location:** Peddapuram
- **Capacity:** 360 MW
- **Comm. Date:** 2002
- **Allocation:** 1.22 MMCMD
- **Deficit:** 0.22 MMCMD
- **New Plant:**
  - Capacity Addition: 360 MW
  - Location: Same
  - Likely Date: 2005/6
  - Fuel Type: Gas
  - FSA Status: Not Yet

Vemagiri Power Generation Ltd.

- **Location:** Vemagiri (near Rajahmundry)
- **Capacity:** 520 MW
- **Comm. Date:** 2003
- **Allocation:** 1.64 MMCMD
- **Deficit:** 0.332 MMCMD
- **New Plant:**
  - Capacity Addition: 700 MW
  - Location: Same
  - Likely Date: 11th Plan
  - Fuel Type: Gas
  - FSA Status: With GAIL

BSES Andhra Power Ltd.

- **Location:** Peddapuram Samalkot
- **Capacity:** 200 MW
- **Comm. Date:** 2001
- **Allocation:** Nil
- **Deficit:** 0.908 MMCMD
- **New Plant:**
  - Capacity Addition: 200MW
  - Location: Kakinada
  - Likely Date: 2006
  - Fuel Type: Gas
  - FSA Status: Not Yet

BBI Power

- **Location:** Krishnapatnam
- **Capacity:** 520 MW
- **Comm. Date:** 2003
- **Fuel:** Imported Coal
- **Source:** Not Decided
- **New Plant:**
  - Capacity Addition: 1500 MW
  - Location: Same
  - Likely Date: 11th Plan
  - Fuel Type: Coal (imported)
  - Switching: Likely (to gas)

Hinduja National Power Corp. Ltd.

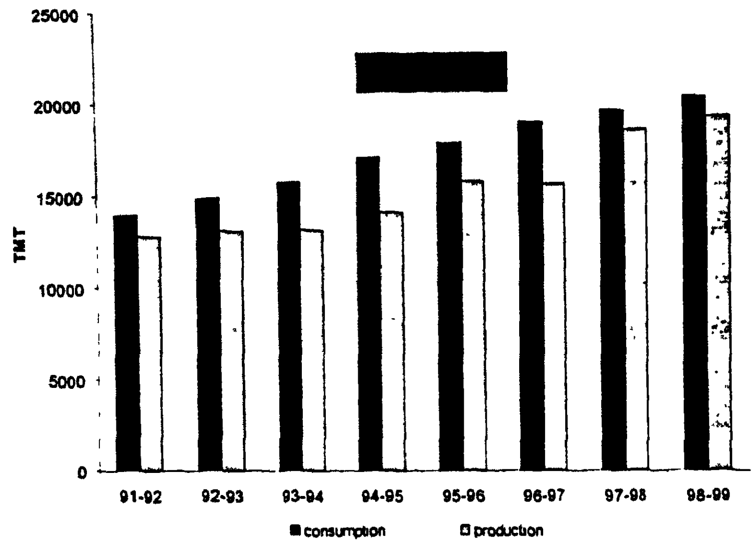
- **Location:** Vishakhapatnam
- **Capacity:** 1040 MW
- **Comm. Date:** 2005 delayed
- **Fuel:** Coal
- **Source:** Talcher (Orissa)
- **Expansion Plans:**
  - Capacity Addition: 520 MW
  - Date: 11th Plan
  - Fuel Type: Coal (imported)
  - Switching: Likely (to gas)

BPL Power Projects Ltd.

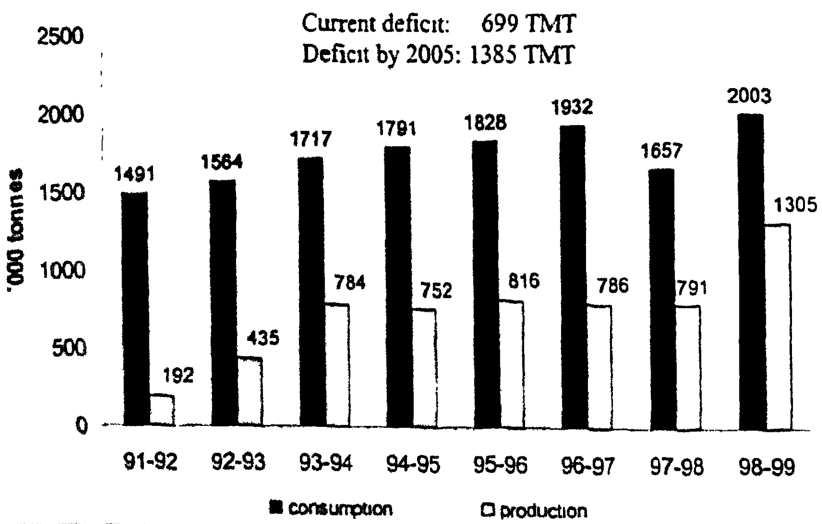
- **Location:** Ramagundam
- **Capacity:** 520 MW
- **Comm. Date:** 2003
- **Fuel:** Coal
- **Source:** Singareni (A.P.)
- **Switching:** Fuel linkage complete
- **Expansion Plans:**
  - None so far

Fertiliser Sector

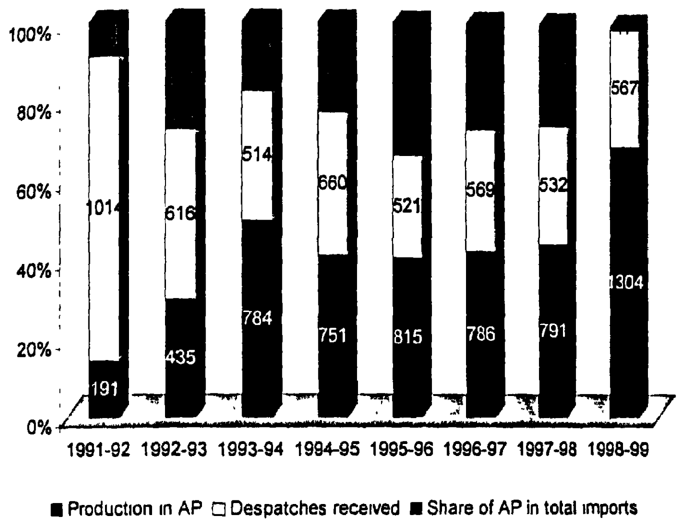
All India Production/Consumption of Urea



Production and Consumption of urea in AP



Sources for urea supplies



Existing production capacity

NFCL

- **Product :** Urea
- **Location** : Kakinada
- **Capacity** : 1 million tonnes
- **Capacity utilization** : ≅ 140%
- **Gas requirement** : 2.75 MMSCMD
- **Gas allocated** : 2.75 MMSCMD
- **Deficit** : Nil
- **Source** : GAIL (contracted till 2007)
- **Expansion Plans** : none

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Policy Changes Under Consideration

- Removal of distribution control on urea - April 2001.
- Increase in the price by 7% yearly.
- Total decontrol of fertilizer sector - April 2006.
- Creation of new capacities for Eastern and Southern zones which are deficit - after 2002.
- Naphtha based capacity not to be allowed.
- Feasibility of coal based units under study.

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Proposed urea plant

- Promoter - IFFCO
- Location - Nellore
- Capacity - 7,26,000 MT/year
- Status - in principle approval by cabinet. Techno-economics appraised by PIB.
- Likely commissioning date 2008
- Likely gas demand - 1.8 MCMD

Imputed Values

[redacted]

Imputed Values of Gas at Kakinada

- For Power Generation

– Against domestic coal	3.60	
	At cif $34	**At cif $40**
– Against imported coal	4.49	4.95

- For Fertiliser Production

– Against imported urea	
• Cif at $150	2.40
– Farmgate price of Rs 9000/T	3.73

Cost of Generation

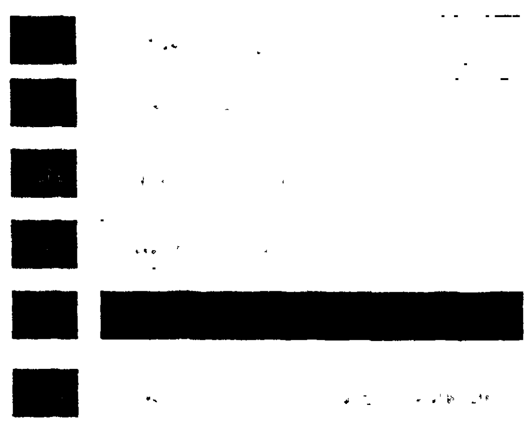
- **LNG / Gas at**

	Cost of generation (Paise/kWh)
– $ 4.16/MMBtu :	223
– $ 4.50/MMBtu :	233
– $ 5.00/MMBtu :	249

- **For Comparison**

– at current naphtha prices	450
– at current gas prices :	180-200
– at current coal prices :	200-220

Gas Supply

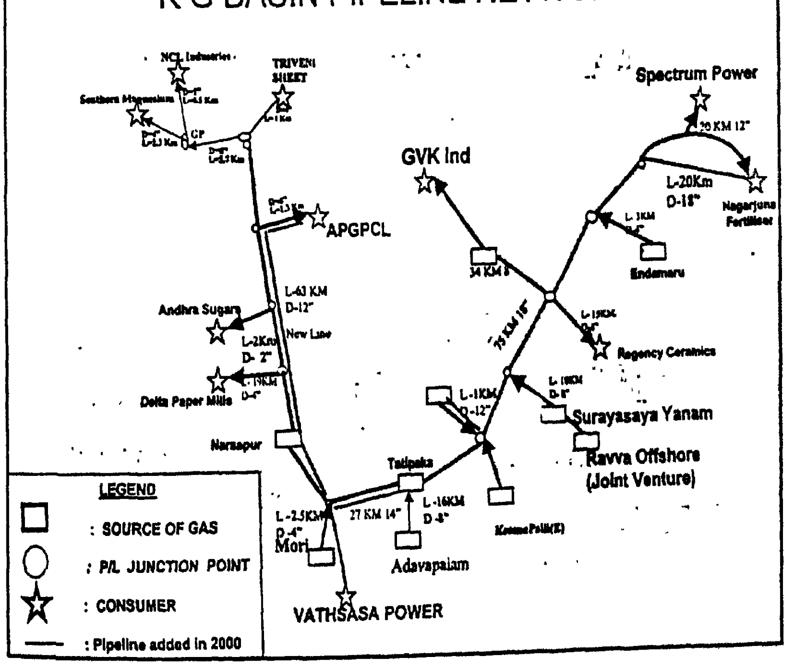


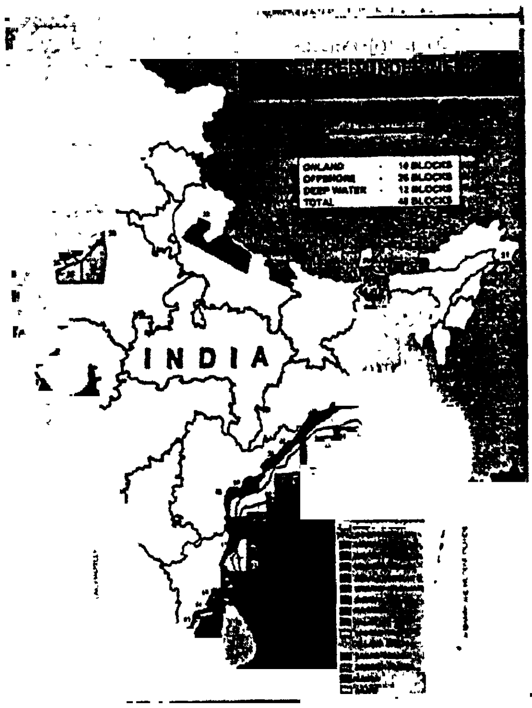
Gas Sales in KG Basin

[redacted]

Year	Fertiliser	Power	Others	Total	% of All India Sales
1997-98	1.37	1.84	0.07	3.28	6.13
1998-99	1.67	2.25	0.06	3.97	7.21
1999-00	1.77	2.47	0.10	4.34	7.70

K G BASIN PIPELINE NETWORK





NELP Blocks

Possible supply sources - NELP

- Hydrocarbon Resources (MMT):

Offshore	Onland	Total
555	575	1130

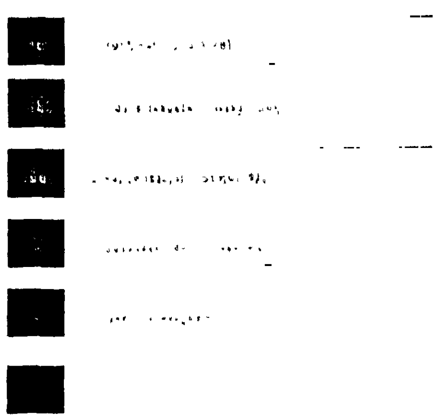
- No of blocks awarded All India:25
- No. of blocks awarded in KG Basin: 9

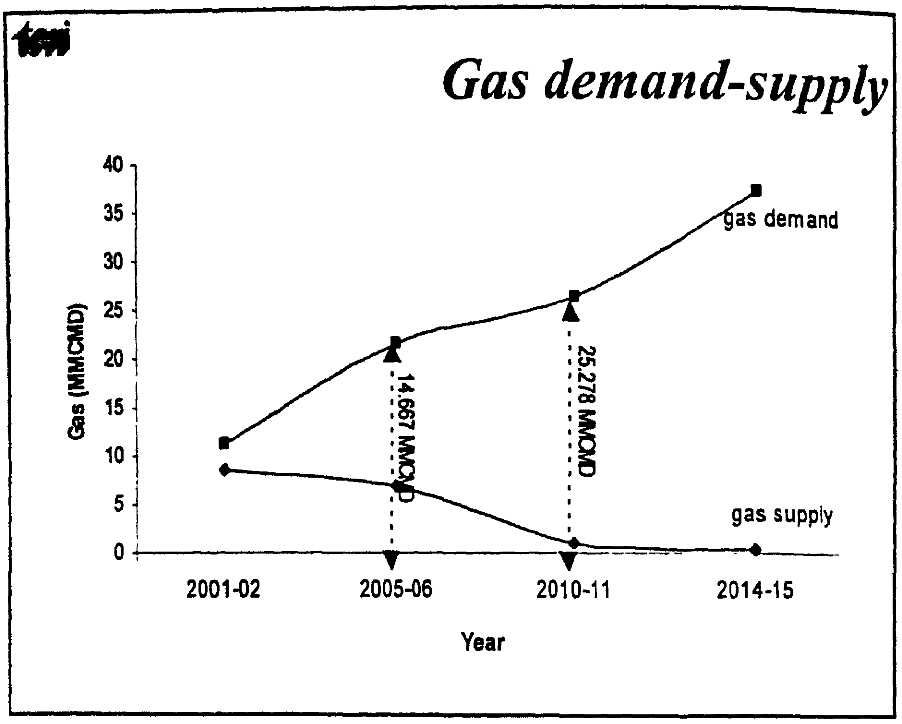
- Exploration expenditure committed (Million USD):
  - All India 248.30
  - KG Basin 156.92

Possible supply sources - Bangladesh

- 1 bcfd pipeline
  - Bangladesh well-head price :$2.2/MMBtu
  - Transportation cost upto Kakinada: $0.80/MMBtu
  - Delivered price: $3.00/MMBtu

Gas Demand Supply Analysis




Gas demand-supply
40
35
30
25
20
15
10
5
0
Gas (MMCMD)
gas demand
gas supply
14.667 MMCMD
25.278 MMCMD
2001-02
2005-06
2010-11
2014-15
Year

teri

Appendix 3: Presentation of Phase II

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A Study on Gas Demand in Andhra Pradesh

Presentation to : BP International Ltd

15th January, 2001

Gas Demand (2015): Power

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

Power Demand Forecasts: Methodology

- Energy requirement (unrestricted) forecast till 2015, based on 1991-1999 trend
- Annual load factor assumed to decline from 72.6% in 1999 to 67% in 2015
- Peak requirement estimated from energy requirement and annual load factor
- Reserve margin of 30% assumed to estimate peak capacity required

teri

Power Demand Forecasts: Andhra Pradesh

Year	Energy requirement (MkWh)	Peak requirement (MW)	Peak capacity required (MW)
2000-01	49185	7773	
2005-06	63413	10270	13351
2006-07	66258	10784	14019
2011-12	80486	13433	17464
2015-16	91868	15652	20348

teri

Comparison of Forecasts: Energy Requirement (MkWh)

Year	TERI	15th EPS
2001-02	52031	45226
2006-07	66258	59812
2011-12	80486	78172

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Comparison of Forecasts: Peak Demand (MW)

Year	TERI	15th EPS
2001-02	8263	7483
2006-07	10784	9824
2011-12	13433	12748

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Installed Capacity (MW)

31 October 2000

Total installed Capacity 7856.62

- APGENCO 5488.50
- Joint & Central Sector 1352.50
- Private sector 1015.62

Likely capacity additions till 2005

Location	Promoter	Fuel Type	Capacity (MW)	Date Comm.
Under construction				
Srisailam LBPH	APGENCO	Hydro	900	2000-03
Peddapuram Samalkot	BSES	Naphtha	200	2001
LVS Power Project	LVS Power Ltd.	LSHS	36.8	2001
Simhadri	NTPC	Coal	1000	2002
Ramagundam-III	NTPC	Coal	234	2003
Talcher-II	NTPC	Coal	425	2004-06
Planned				
Jeggurupadu (expansion)	GVK	Gas	220	2004
Peddapuram	Gautam Power & NCC	Gas	477	2004
Vemagiri	Vemagiri	Gas	520	2004
Konaseema	Oakwell	Gas	360	2005
Ramagundam	BPL Power Projects	Coal	520	2005

Likely capacity addition: 2005-2015

Location	Promoter	Fuel Type	Capacity (MW)	Date Comm.
Rayalsema – II	APGENCO	Coal	420	2006
Kakinada (expansion)	SPGL	Gas	360	2006
VTPS	APGENCO	Coal	660	2007
Krishnapatnam –A	GVK Industries	Coal (IMP)	520	2007
Jaurala	APGENCO	Hydro	110	2008
Vishakhapatnam	HPCL	Ref. Res.	585	2009
Vishakhapatnam	HNPCL	Coal	1040	Delayed
Krishnapatnam	M/S BBI Power	Coal (IMP)	520	Delayed

Demand - Supply Gap (MW)

2005

Required capacity:	13351
Likely capacity:	12749
Capacity deficit:	601

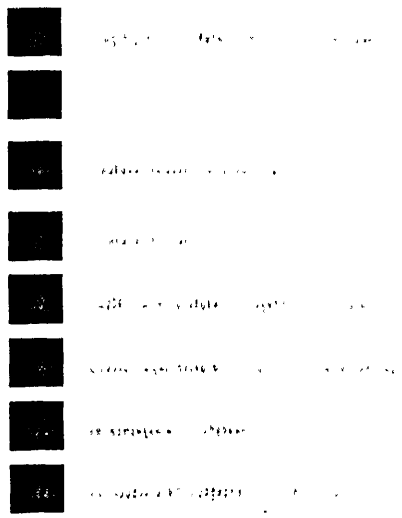
2015

Required capacity:	20348
Likely capacity:	15404
Capacity deficit:	4944

Meeting the Deficit: 2015

• CPSUs (Southern):	1000 MW
• Hydro :	300 MW
• Mini Hydel/Wind/Biomass:	200 MW
• Coal:	1088 MW
• Gas:	2356 MW

Gas Demand (2015): Fertiliser



Fertilizer Demand Projections for India (2012)

(MMT)

- Projected Food-grain Production 337.3
- Requirement of Fertiliser 40.7
- Requirement of Urea 46.4

Fertilizer Demand Projections for Andhra Pradesh (2015)

(MMT)

- Method 1 (Trend Analysis)
  - Nitrogenous Fertilizer 2.1
  - Urea 3.8
- Method 2 (Based on area and yield of rice)
  - Nitrogenous Fertilizer 1.6
  - Urea 2.8
- Method 3 (6 % rate of production growth)
  - Nitrogenous Fertilizer 4.2
  - Urea 7.5

Gas Demand for Fertiliser

(MMCMD)

2005	**2.75**
2010	**4.55**
2015	**4.55**

Industrial Units Surveyed

Format of official data on industrial units

- Name of unit
- Registered Address
- Add. Of Factory
- Contact Person
- Capacity
- NIC
- Total Investment
- Year of Prod.
- Ownership
- Collaborator Name

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Types of Industries

Category of Industry	No. of Units
231	72
319	63
315	51
367	41
324	37
340	36
206	32
313	32
354	26
331	23

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Target Industrial Sectors

- Cement
- Pulp and Paper
- Glass
- Ceramics
- Chemicals
- Sugar
- Refractories

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Units Surveyed

District	Type	No.
Anantapur	Ferro-alloys,Cement	3
East Godavari	Refrac., Ceramics,Paper and Sugar	7
Guntur	Cement	2
Hyderabad	Glass and Ceramics, Pharma, Chemicals and Ors.	5
Khammam	Ferro-alloys, Paper	2

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Units Surveyed (contd.)

District	Type	No.
Krishna	Cement	2
Vishakhapatnam	Cement	1
Nalgonda	Cement	5
Ranga Reddy	Paper and textiles	2
Srikakulam	Ferro-Alloys	1

Units Surveyed (contd.)

District	Type	No.
Medak	Refractories and Pharma	4
Warangal	Paper	1
West Godavari	Sugar	1
Total No. of Units Surveyed:		**36**

Andhra Paper Mills

Annual capacity:	109500 t.p.a
Type of fuel :	Coal (domestic)
Quantity used:	2 lakh t.p.a
Location:	Rajahmundry, E.Godavari
Capacity of captive units:	24 MW
Technology for switching :	Available
Willingness to switch:	Willing
Considerations for switching:	Price, stable supply
Expansion Plans :	10,000 t.p.a
Time Frame:	2002

teri

Madras Cements

Annual capacity:	1.35 Million t.p.a	
Type of fuel :	Coal (dom. & imp.)	Rice-husk
Quantity used:	1.35 mn t.p.a.	0.1 mn t.p.a
Location:	Jaggayapet, Krishna	
Capacity of captive units:	20 MW	
Technology for switching:	Not Available	
Willingness to switch:	Yes	
Considerations for switching:	Cost, price, supply	
Expansion Plans:	None	
Time Frame:	N.A.	

teri

AGI Glaspac

Annual capacity:	100 MT
Type of fuel :	Coal & LSHS
Quantity used:	9000 t.p.a & 6000t.p.a
Location:	Hyderabad
Capacity of captive units:	5 MW (standby)
Technology for switching:	Available
Willingness to switch:	Yes
Considerations for switching:	Price; supply
Expansion Plans:	50 MT
Time Frame:	2003

teri

Regency Ceramics

Annual capacity:	76,000 t.p.a
Type of fuel :	Natural Gas
Quantity used:	0.145 MMSCMD
Location:	Yannam, W.Godavari
Capacity of captive units:	Nil
Technology for switching:	Exists
Willingness to switch:	N.A.
Considerations for switching:	N.A.
Expansion Plans :	76,000t.p.a
Time Frame:	2001

teri

Navbharat Ferro-Alloys

Annual capacity:	25,000 t.p.a
Type of fuel :	Coal and Electricity
Quantity used:	4.5 lakh t.p.a. & 50 MW
Location:	Paloncha, Khammam
Capacity of captive units:	30 MW
Technology for switching:	Not Available
Willingness to switch:	N.A.
Considerations for switching:	N.A.
Expansion Plans :	None
Time Frame:	N.A.

teri Gas Demand from Units Surveyed

(MMCMD)

District	Type	Demand
Anantapur	Ferro-alloys,Cement	0.68
East Godavari	Refrac., Ceramics,Paper and Sugar	0.26
Guntur	Cement	0.18
Hyderabad	Glass and Ceramics, Pharma, Chemicals and Ors.	0.04
Khammam	Ferro-alloys, Paper	0.14
Krishna	Cement	0.22

contd...

teri Gas Demand from Units Surveyed

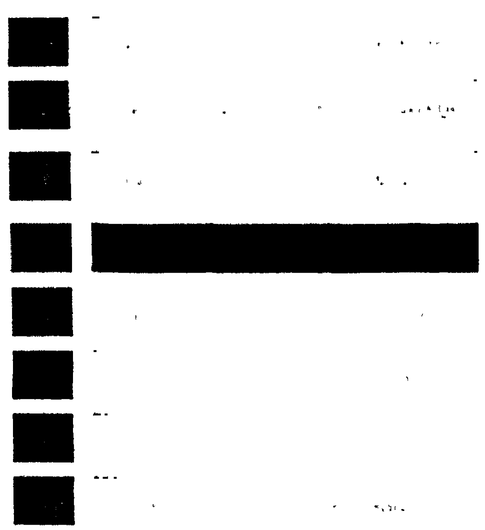
(MMCMD)

District	Type	Demand
Medak	Refractories and Pharma	0.003
Nalgonda	Cement	0.78
Ranga Reddy	Paper and textiles	0.07
Vishakhapatnam	Cement	0.24
Warangal	Paper	0.03
West Godavari	Sugar	0.01

Gas Demand from Units Surveyed

Current Demand	2.64 MMCMD
Demand from expansion projects (upto 2005)	0.22 MMCMD

Industrial Gas Demand



Current Industrial Gas Demand

(MMCMD)

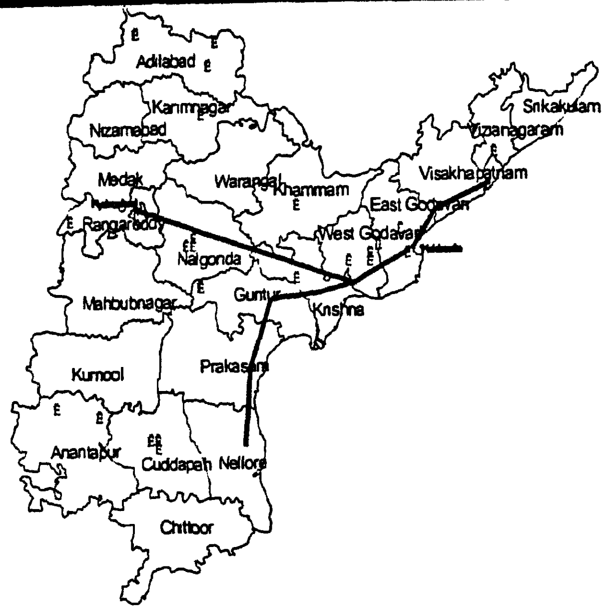
Entire State	7.31
Along Pipelines	5.70

Projected Industrial Gas Demand

(MMCMD)

	Entire State	Along Pipelines
2005	9.22	7.19
2010	12.34	9.63
2015	16.52	12.88

Proposed pipeline alignment in Andhra Pradesh



Gas Demand : Captive Units

Captive Power Generation (MW): 1998 - by fuel use

• Coal	689.6
• Diesel	575.6
• Gas	24.2
• Naphtha	21.0
• Hydro	2.0

Current Gas Demand: Captive Generation (MMCMD)

• **State**	0.08
• **Along Pipelines**	0.08

Projected Gas Demand: Captive Generation

(MMCMD)

	State	Along Pipelines
2005	1.30	1.01
2010	1.30	1.01
2015	1.30	1.01

Gas Demand : City Distribution

Urban agglomerations in Andhra Pradesh



Gas Demand for City Distribution: 2015

(MMCMD)

• State	2.04
• Along Pipelines	
– Alignment I	0.58
– Alignment II	1.26
– Alignment III	0.33

City Distribution planned by IGL

City/Town	
Kakinada	Ramachandrapuram
Rajahmundry	Bhimavaram
Amalapuram	Palakollu
Mandapeta	Narsapur
Tanuku	Vizag
Tuni	Elamanchili

Total estimated demand 5.8 MMCMD

Imputed Values

Imputed Values for Gas Use

($/MMBtu)

Location	Domestic Coal at LRMC	FO at crude price $20/bbl
Visakhapatnam	1.62	3.92
Rajahmundry	1.79	4.26
Nellore	2.12	4.49
Hyderabad	2.21	4.59

Imputed Values for Gas Use

($/MMBtu)

Location	LPG at crude price $20/bbl
Visakhapatnam	7.46
Rajahmundry	7.62
Nellore	7.92
Hyderabad	8.00

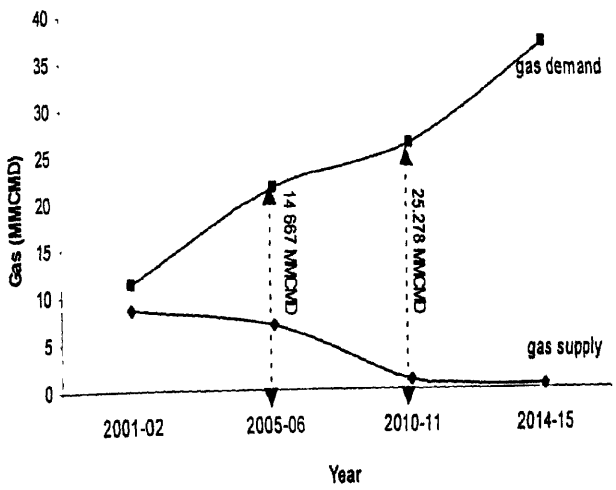
Demand-Supply Analysis

Aggregate Gas Demand

(MMCMD)

Year	Industrial	Fertiliser	Power	Captive	City distribution	Total
2001	2.64	2.75	5.86	0.08	0	11.33
2005	2.86	2.75	14.26	1.01	0.62	21.5
2010	3.83	4.55	15.76	1.01	1.07	26.22
2015	5.12	4.55	24.76	1.01	1.67	37.11

Gas demand-supply



Thank You !

Appendix 4: Overview of the Indian gas industry

Oil and gas were discovered in India in 1886, with a non-commercial oil well in Upper Assam. The Naharkatyia oilfield in Assam was the first oil and gas discovery of independent India in 1953, followed by the discovery of the Moran field in 1956. Commercial utilization of natural gas in India started in the early sixties in Assam but really picked up after the development of the giant Bombay high field in the early eighties. Subsequently, South Bassein, another very large gas field was discovered in 1978 in the Western Offshore and brought into production around 1990.

The early focus was on oil production and as a result large amount of associated gas from producing oil fields was flared due to a lack of infrastructure and markets. Free gas field finds were shut in for the same reason.

It was only in the early 1980's that the western offshore gas began to be exploited as a resource rather than being treated as a by-product. The government appointed a number of committees and expert groups to examine the ways in which the gas could be best utilized. The view that emerged was that the optimal use of gas would be in producing fertilizers. Initially there was quite some opposition to the use of gas for power generation but later the idea was accepted. In 1986 work began on the Hazira-Bijaipur-Jagdishpur (HBJ) gas transmission line linking the western offshore gas fields with fertilizer and power consumers. This resulted in significant growth in gas production and use through the late 1980's. Flaring from the western offshore has diminished substantially in recent years and is now limited to only technical flaring.

Associated gas has been produced in Assam for over 20 years but flaring has remained at high levels till recently. Free gas fields in Tripura are being used mainly for power generation. Some associated gas is being produced in Arunachal Pradesh but utilization by a proposed gas-to-liquid plant is yet to start. Consequently, this gas has to be flared.

The fields in Rajasthan, Tamil Nadu and Andhra Pradesh were exploited during the 1990's. The gas produced off the coast of Andhra Pradesh in the Ravva field is being utilised since 1997.

Gas reserves and production

Gas reserves

The proven and balance recoverable reserves of natural gas by State, from 1975 to 1999 have been tabulated below.

State-wise Reserves of Natural Gas (BCM)

Gas Reserves (BCM)	*1975*	*1980*	*1985*	*1990*	*1995*	*1998*	*1999 (P)*
Onshore							
Gujarat	15.72	16.39	21.87	92.58	89.88	84.24	-
Assam	65.24	63.53*	87.67*	135.47*	159.18*	187.73	-
Rajasthan	0.43	0.43	0.54	1.04	4.11	4.44	-
Total	81.39	80.95	110.08	229.09	253.17	276.41	279
Offshore							
Bombay High	6.28	270.96	368.55*	457.36	406.47**	398.34	369
Grand Total	87.67	351.91	478.63	686.45	659.64	674.75	648

* includes natural gas reserves in Tripura, Nagaland Tamil Nadu, Arunachal Pradesh & Andhra Pradesh

** includes natural gas reserves in Andhra Pradesh, Gujarat, Tamil Nadu, Andaman and JVC

Source: Indian Petroleum & Natural Gas Statistics - 1997-98 and 1998-99, Ministry of Petroleum & Natural Gas, Govt. of India

As per the Basic Statistics on Indian Petroleum and Natural Gas (Ministry of Petroleum and Natural Gas, Government of India, August 1999), the onshore and offshore gas reserves (provisional) in the country in 1998 and 1999 were as follows.

Gas reserves in 1998/99

Natural gas reserves (BCM)	1998	1999*
Onshore	277	279
Offshore	398	369
Total	675	648

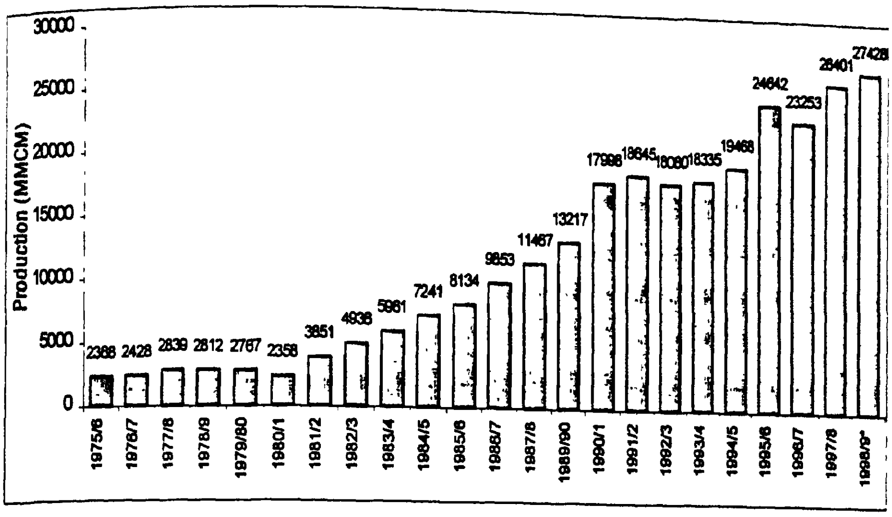
* Provisional

Gas reserves have been declining over the last few years and unless reserves in existing fields are significantly upgraded or new fields discovered and brought on stream, gas production is set to decline from its current level.

Gas production

Natural gas production and development in India has grown from 2.4 BCM in 1975/76 to 27.4 BCM in 1998/99.

Gas production in India in million cubic metres



* Provisional

Source. Indian Petroleum & Natural Gas Statistics - 1997-98 and 1998-99, Ministry of Petroleum & Natural Gas, Govt. of India

There are five major areas of gas production in India today:

- The Western Offshore region which extends from offshore Bombay to Gujarat
- Gujarat, were there are two producing areas
- The Krishna Godavari basin
- The Cauvery basin
- Assam and Arunachal Pradesh

Currently around 75% of India's gas is being produced from the western offshore fields but this production is now in decline.

Gas supply sector organisation

The gas supply sector in India is dominated by public sector enterprises under the administrative control of the Ministry of Petroleum. Ninety percent of the gas is produced by two state owned oil companies, the Oil and Natural Gas Corporation (ONGC) and Oil India Limited (OIL). The balance comes mostly from two medium sized fields operated by joint ventures of ONGC.

Although the state owned enterprises increased hydrocarbon production and reserves base significantly over the period 1975 to 1990, the gap between domestic production and demand widened significantly in the later years. As a result initiatives were taken to encourage private sector investment into the exploration and production activities, with exploration acreage offered to private

companies under production sharing arrangements with the Indian government. The medium sized fields – Panna, Mukta, Tapti and Ravva – operated by private parties account for 10% of the gas production. Several small gas fields are also operated in the private sector but their production does not add up to much.

The gas produced by ONGC and the joint ventures is marketed by GAIL. OIL, which operates mainly in Assam and also in Rajasthan has its own marketing arrangements. GAIL and OIL sell gas only to consumers who are allocated gas by the Government of India while the private operators are free to select their customers. The gas price to be charged by ONGC and OIL and the transportation charges along the HBJ pipeline of GAIL are fixed by the government. Gas from private fields is sold at negotiated prices.

The gas industry infrastructure

By far the largest of the transmission systems is the HBJ (Hazira-Bijaipur-Jagdishpur) line of GAIL. This pipeline (2,300 km) transverses the states of Gujarat, Madhya Pradesh, Rajasthan, Uttar Pradesh, Haryana and Delhi. The capacity of HBJ system has been augmented from 18.2 MMCMD to 33.4 MMCMD in July 1998. As part of the expansion plan, a trunk section (36 inch in diameter) has been added between Bijaipur and Dadri.

In addition to the HBJ pipeline, there also exist regional gas grids of varying sizes, in the states of Gujarat, Andhra Pradesh, Assam, Maharashtra, Rajasthan, Tamil Nadu and Tripura. These regional pipelines (about 725 km) were constructed and operated by ONGC, but with the commissioning of the HBJ pipeline in the late eighties, ownership and operatorship of these gas grids were passed on to GAIL. The present grid capacity is based on the gas availability from the producing areas as well as the outlook for future gas production. In view of the increased availability of gas in the KG basin, GAIL has announced plans for augmenting pipeline capacity in Andhra Pradesh. The feasibility of expanding the HBJ pipeline capacity to 60 MMCMD is also under examination. This capacity expansion is proposed in view of the proposals to import LNG into Gujarat.

Distribution

At present, natural gas distribution systems are confined to a few cities in Gujarat, supplied by the Baroda Municipal Corporation (BMC) and the Gujarat Gas Company (GCC), together with a number of towns in Assam supplied by the Assam Gas Company (AGC) and a small system in Tripura. In recent years,

offshoots from the main HBJ pipeline has also led to the development of a reticulated system in New Delhi supplying gas to a thousand houses and to CNG filling stations. The Mahanagar Gas Limited, a joint venture between GAIL and British Gas is supplying gas to around 30,000 houses in Mumbai as well as industrial and commercial units and CNG filling stations. Foundaries and glass blowing units in Agra and Ferozabad are supplied gas through a local network.

Exploration prospects and present activity

Sedimentary basins in India

Sedimentary basins are a good prospective source of gas in India. The basins extend over 1.39 million square kilometres onshore, 0.4 million square kilometres offshore and about 1.35 million sq. km in deep water.

The various basins have been categorized according to their prospectivity; Category I consist of producing basins, while Categories II to IV are basins with reducing prospectivity. The Category I basins consists of:

- Cambay Basin, Gujarat
- Bombay Offshore
- Cauvery Basin
- Krishna-Godavari Basin
- Assam Shelf/Assam Arakan Fold Belt

Early E&P activities (during the 1960's and 1970's) were concentrated in category I basins but since the early 1980's efforts were increased into unexplored areas, in particular offshore acreage.

The three main producing basins in the country, the western offshore region, the Cambay basin in Gujarat, and Upper Assam region, are in the mature phase of exploration and with the exception of Assam, future finds in these areas are not likely to be large in size. The potential for new discoveries in the western offshore/Cambay basin area is low. The area has been well explored since the 1970's and the prospect of a major find is widely believed to be small.

The performance of Bombay high field has been adversely affected due to a number of management and development problems, but it is believed to have good potential for increases in reserves and production.

There has been a sharp increase in gas availability in Andhra Pradesh recently. The availability is likely to further increase as a number of offshore blocks have been awarded for exploration under the NELP and these blocks are

considered promising. However, exploration carried out there so far has not produced any result.

Alternative sources of gas

Coal bed methane (CBM)

The production of natural gas from coal – coal bed methane (CBM) – has been undertaken from coal deposits in several countries over the last decade, and in the United States coal bed methane is extracted on a commercial basis. Coal Bed Methane (CBM) is primarily a methane gas, which occurs in coal seams. The volume of exploitable gas depends upon its quality and depth of burial. CBM is an environment-friendly fuel and its exploration reduces mining safety hazards in coal mining.

India holds significant prospects for exploitation of CBM as a new source of energy. There are about 200 billion tonnes of coal reserves predominantly in the eastern part of India – Bihar, West Bengal and Madhya Pradesh. It is estimated that 70 –75 billion tonnes of coal reserves are beyond 600 metres and thus not mineable by the current mining technologies. These reserves would potentially be available for exploitation of CBM. The existence of gaseous mines is well established in India, notably in Damodar Valley coal fields. Analysis of coal in the Damodar Valley has indicated that upto 10 cubic metres or more of methane gas per tonne of coal may be present at a medium depth of burial.

There are also large coal/lignite reserves in Gujarat at the depth of 1,000 – 1,500 metres, which are not exploitable with conventional mining techniques. It has been estimated that the coal reserves could be of the order of 65 billion tonnes. Therefore, Gujarat coals can also be an attractive target area for commercial CBM projects. The Shobhasan coals in North Gujarat area could be the main target for CBM whereas the Kalol coals can provide secondary target. GAIL and ONGC have agreed to jointly undertake a project for assessing the CBM potential of coal deposits in north Gujarat area.

After taking into account the future coal- mining programme by coal companies, 9 blocks have been identified in consultation with Ministry of Coal for CBM operations. Out of 9 blocks, except North Raniganj, where ONGC has already started CBM activity on nomination basis, all 8 blocks are proposed to be offered for exploration and exploitation through global competitive bidding route by Government of India after getting clearance of CBM policy from respective states. Prognosticated CBM resource position as per the estimates of

Directorate General of Hydrocarbons (DGH) in these 9 blocks are around 400 BCM.

Prognosticated CBM resource position

Sl. No	Coalfield	Block/State	Area covered (in sq. k.m.)	Prognosticated CBM resource (in TCF)
Gondwana Coal				
1.	Raniganj	Norhtern Raniganj (West Bengal)	232.00	1.030
2.	Raniganj	Eastern Raniganj (West Bengal)	500.00	1.850
3.	Jharia	Southern part of Jharia Coalfield (Bihar)	69.20	2.407
4.	Bokaro	Bokaro Basin (Bihar)	93.97	1.590
5.	Birbhum	Birbhum (West Bengal)	250.00	1.000
6.	N. Karanpura	N. Karanpura (Bihar)	340.54	2.181
7.	Sohagpur	Eastern Sohagpur (M.P)	495.00	3.030
8.	Sohagpur	Western Sohagpur (M.P)	500.00	
9.	Satpura	Satpura Basin (M.P)	500.00	1.000
	Total		2980.71	14.088 or 398.92 BCM gas in place

Source. Hydrocarbon Vision 2025, GoI

These prognosticated resources can yield an average production level of 22 MMSCMD for a period of 25 years, assuming a recovery factor of 60%.

Gas hydrates

The presence of large quantities of gas hydrates in Indian deep sea offshore has been identified by the Directorate General of Hydrocarbons (DGH) as a potential future source of gas, most notably in the Andaman area. The DGH has estimated that on the east and west coasts of India the gas hydrate resource base could be as large as 12,000 trillion cubic metres. This estimate assumes that availability of methane gas for hydrate formation would not be a constraint in the Indian offshore region due to very favourable thickness of the sediments as well as the presence of organic contents.

The DGH has prepared for the Ninth Five-Year Plan, a National Gas Hydrate Programme with an outlay of Rs.213 crores. The programme, to be implemented in a phased manner, would involve detailed examination of existing geological and geophysical data, acquisition and processing of fresh seismic data, stratigraphic drilling and completion of 3/5 wells. However, the current pace of development activity is slow and needs a massive effort to make gas from this source available to India.

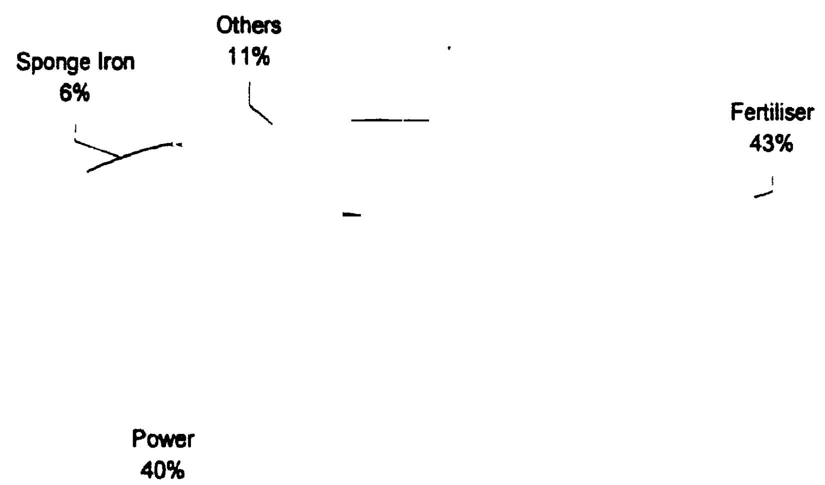
Demand for natural gas

Past trends in gas demand

Although the use of natural gas has increased rapidly, natural gas accounts for only around 7-8% of the primary energy in use. Till the late 1980's the demand lagged behind the supply mainly because of lack of infrastructure. However, in the 90's, the demand has exceeded supply.

Government of India regulates all gas allocations. The power and fertilizer sectors have been allocated most of the gas. These two sectors together consume about 80% of the gas today. The sponge iron units consume another 10%. The balance goes to industrial units where it replaces mostly fuel oil and some LPG also. Gas is also supplied to the residential and the commercial sectors in Mumbai, Delhi and a few towns of Gujarat, Assam and Tripura. This gas is used for cooking only, as space heating is not required. The daily requirement of households is only around 1 cum. With such low requirements and the subsidy on domestic LPG, the demand from this sector will continue to be low. The use of CNG in lieu of petrol has been popular in Mumbai but less so in Delhi. In any case, this sector can consume only small volumes.

Gas sales in India (1998/99)



Source. GAIL

Area wise use of natural gas in 1998/99 is summarized in table below:

Gas utilization: 1998/99 (MMCMD)

Area	Fertilizer	Power	Sponge Iron	Others	Total
Western Offshore:					
Uran	5.0	4.7	1.4	0.7	11.8
HBJ	13.0	9.1		2.5	24.6
Hazira	2.7		2.0	1.2	5.9
Western Onshore	1.2	4.2		1.4	6.8
Rajasthan		0.4			0.4
K. G. Basin	1.7	2.2		0.1	4.0
Assam	0.0	0.4		0.1	0.6
Tripura		0.8		0.0	0.8
Cauvery Basin		0.0		0.1	0.1
Total	23.6	21.9	3.5	6.1	55.1

Source. GAIL

Gujarat uses more gas than any other state in India.

Gas use in fertilizer industry and power generation

The fertilizer industry is currently the largest single gas consumer in India accounting for about 44% of the total sales. Gas utilization for fertilizer production in India started in earnest in the early 1980s only. It is one of the feedstocks used in production of nitrogenous fertilizers. In India, bulk of the production of nitrogenous fertilizers is in the form of urea.

The choice of feedstock for fertilizer production has been primarily determined on the basis of availability of feedstock and government policies in place. The demand for gas for fertilizer production, however, exceeds domestic availability. Immediately following the fertilizer industry, the power sector is the second largest consumer of gas in India.

Other industries

Gas utilization is preferred in industries where heat control and low sulphur are prerequisites in the fuel used such as glass, ceramics, textiles, electronics (picture tubes) etc. It is also used in the sponge iron (or Direct Reduction to Iron – DRI) industry and in the production of methanol.

The sponge iron industry

In the sponge iron industry, natural gas is used as a primary energy agent for the reduction of iron oxides into metallic iron, either in the form of Hot Briquetted

Iron or iron carbide, for subsequent use in the manufacture of steel slabs and billets. DRI is a substitute for the use of scrap as a feedstock in arc and blast furnaces. Two main gas-based DRI processes exist, the Midrex and the HYL-III processes. The former is currently used in India by both Essar and Ispat at Hazira and Raigarh respectively, whilst the latter is used by Grasim, also at Raigarh. There are plans for the construction of new plants in the Kakinada area and Madhya Pradesh, and additional capacity in the Bombay area.

In the production of methanol

Natural gas is the dominant feedstock for world production of methanol, through the partial oxidation of natural gas. Methanol itself is one of the major basic chemical raw materials. At present methanol production in India from gas is limited to a single plant in Gujarat operated by Gujarat Narmada Fertilizer Company.

The glass and ceramics industry

Gas is used in the glass and ceramics industry to fire furnaces in which the raw materials, fluxes and oxidising agents are mixed. The demand from the glass industry is relatively low – a typical glass plant would consume no more than 0.1 MMCMD. The glass industry will be a willing consumer of gas over other hydrocarbon fuels but will not provide the quantity of demand necessary to support any gas infrastructure project.

Other areas of gas use

Gas is also used in industries for process heating and steam–raising. Oil refineries might also use some gas to produce H_2 for de-sulphurisation and hydro-cracking but the required quantities would be small.

The domestic sector

For domestic consumers, the main use of gas will be in replacing kerosene and LPG for cooking purposes. Piped gas for domestic use has been made available in a few cities in India. These include the cities of Surat, Vadodara and Ankleshwar in Gujarat; Mumbai in Maharashtra and Delhi. In all these cases, domestic consumers have piggybacked on large consumers as the volumes associated with city distribution alone render such projects unviable.

Expected future trends in gas demand

The demand for gas up to 2025, the indigenous supply and the deficit have been examined by the Sub-Group on Development and Utilization of Natural Gas as a part of the exercise to prepare a Hydrocarbon Vision 2025 of the Govt. of India. The requirement of gas over the time horizon upto 2025 would depend upon a number of factors and their complex inter-relationship. The growth in energy consumption would depend upon the growth of population and of GDP, the structural changes in GDP, the growth of industrial and agricultural sectors, energy pricing and tariffs, the success of energy conservation measures based on the need to contain damage to the environment.

So far as the future gas demand is concerned, an analysis of the dynamics in the power and fertilizer sectors needs to be undertaken to decide the role that gas will play in these sectors. Sales to the fertilizer sector dominate the consumption in the country, followed by sales to the power sector. These two sectors are expected to dominate the demand pattern in the future too. The power and fertilizer sectors are the key sectors in forecasting the demand for gas in India, both because of their role as anchor customers and the expected growth in their size.

Total Gas Demand (MMCMD)

	1998/99	*2001/02*	*2006/07*	*2011/12*	*2024/25*
Power					
Scenario 1*	22	40	67	90	153
Scenario 2**	22	67	119	168	208
Fertiliser	24	54	66	83	105
Others#					
Scenario 1	9	23	33	43	64
Scenario 2	9	30	46	63	78
Total					
Scenario 1	55	117	166	216	322
Scenario 2	55	151	231	313	391

* gas at $4/MMBtu

** gas at $3/MMBtu

\# other sectors account for 20% of total demand in 2002 and thereafter

Source: Hydrocarbon Vision 2025, GOI

Future gas production projections

ONGC draws up long term profiles of gas production every year. These are based on development plans already finalized as well as in anticipation of future discoveries. Current projections show that the total gas production would rise marginally up to 2001. Thereafter the production would decline steadily until the Bombay High gas cap is brought into production. This is expected between the years 2015 and 2020.

Demand - supply balance

The declining production profile coupled with the projection of rising demand shows a widening demand-supply gap. This implies that exploration efforts need to be stepped up and the feasibility of importing gas from the neighbouring countries examined seriously. The initiatives and prospects for exploration have been described earlier. A number of options for importing gas through pipelines and as LNG have also been examined or are being examined, as is the prospect of utilizing domestic coal-bed methane reserves.

Domestic gas price

The price of gas sold by ONGC and GAIL, price of gas from fields operated by joint ventures and also transportation charges along the HBJ are fixed by the Government. Gas from private fields are sold at negotiated prices.

In 1997, the Government announced a phased linkage of gas prices to import parity price of a basket of fuel oils. The gas price in 1997/98 was 55% of the import parity price of the basket of fuel oils. This was increased subsequently to 65 % and 75% in the next two years. This price is subject to a cap of Rs 2,850/ thousand cubic metres and a floor of Rs. 2150/ thousand cubic metres. Royalty at 10%, transportation charges and local taxes are payable in addition. The transmission charge along the HBJ pipeline is Rs. 1150/ thousand cubic metres. In Andhra Pradesh, the transportation charges range upto Rs.700/thousand cubic metres.

The Ministry of Petroleum and Natural gas is reportedly contemplating full parity with fuel oil in which case the domestic gas price would increase to about Rs. 6000/thousand cubic metres.

Import options

As noted before, allocation/demand for gas has outstripped the supply in India. Projections for future demand show a widening deficit. Accordingly, a number of gas import projects have been talked about. Gas can be imported either as Liquefied Natural Gas (LNG) or transported by pipelines.

Pipeline gas import projects

Gas transported by pipeline is usually cheaper than by LNG over short distances. A typical rule of thumb used is that pipeline gas is cheaper for distances up to 3 – 4,000 km for an onshore pipeline and up to 1 – 2,000 km for an offshore pipeline. This rule must be qualified against gas quantities, type of terrain, water

depth etc. but serves as a very general guide. The proposals for importing gas through pipelines have had different fortunes as outlined below.

Oman – India deep water

An in-principle agreement was signed by the governments of India and Oman in September 1994 for the import of 56.6 MMCMD (million cubic metres per day) of gas through two sub-sea pipelines. The gas from the first pipeline was to be utilized in western and northern India and the second was planned to be taken to south India. In order to avoid the territorial waters and the Exclusive Economic Zone (EEZ) of Pakistan, a deep-sea route was proposed. Parts of the route lay at water depths exceeding 3000 metres. The Oman Oil Company could not develop the necessary technology to lay pipelines at that depth. Also, the proven gas reserves in Oman did not conform to the level required to support both the pipeline and the LNG Projects. As a result, the pipeline proposal has not been seriously pursued after 1997.

Iran – India - Pakistan

India and Iran signed a MoU in 1993 to study the feasibility of importing 50-75 MMCMD of gas through a pipeline landing in Kachchh in India. A shallow offshore route through the EEZ of Pakistan was proposed. A feasibility study was awarded to PLE of Germany. However, work o the feasibility study could not be started as the government of Pakistan did not permit a offshore surveys outside the territorial waters off the coast of Pakistan. An onland alternative through Pakistan has also been under consideration. Pakistan had favoured a pipeline route passing overland through its territory allowing it to tap some gas also but no progress is expected soon in view of the strained relations between India and Pakistan at the moment.

Bangladesh-India Pipeline

Various multinational oil companies like Unocal and Shell have indicated that Bangladesh has enough gas reserves, over and above indigenous requirement, which could be profitably exported to India.

Unocal has proposed to export 5BCM of gas per annum to India from the Bibiyana fields through a 1350 km long pipeline from Rashidpur in Bangladesh, which will pass through West Bengal, Bihar and Uttar Pradesh and connect with the HBJ line.

Shell too proposes to export gas to India from the Sangu fields in Bangladesh via a pipeline which will also connect with the HBJ.

However there is strong political opposition in Bangladesh regarding gas exports to India.

Myanmar – Bangladesh – India

There are several proposals for importing gas from Bangladesh. GAIL has an MOU with Cairns Energy / Shell and Halliburton for the study of a 28 MMCMD pipeline from Myanmar via Bangladesh. The proposed alignment covers the eastern portion of Karnataka. Myanmar is yet to prove sufficient gas reserves but exploration off the Myanmar cost is on. Bangladesh has over 300 BCM of gas reserves but the government believes that the gas is required for domestic consumption. The project is critically dependent on clearance from the Bangladesh government. MNCs who have invested in gas exploration in Bangladesh are actively seeking this clearance as they see India as the only market.

Turkmenistan – Afghanistan – Pakistan – India

One other proposal was pursued by Unocal of USA, under the Centgas consortium, for bringing gas from Turkmenistan's Dauletabad fields to markets in northern Pakistan, with the potential of an extension from Multan to New Delhi, India. They have since withdrawn from the venture on account of the situation in Afghanistan.

Qatar – India

A proposal for bringing gas by pipeline from Qatar through Pakistan has been promoted by Crescent Company of Sharjah but little progress has been made.

All the projects listed above are considered economically viable. The problems are political in nature. It is hoped that the problems would be sorted out but it would be impossible to say when these projects could materialize.

Import of LNG

LNG is produced from natural gas through liquefaction, which cools the gas to minus 160^{0}C and reduces the gas to almost $1/625^{th}$ its original volume, thereby allowing it to be transported efficiently over long distances in special purpose tankers. The liquefaction facility is typically referred to as a "LNG train". At the receiving terminal, LNG is regasified and transported through pipelines like natural gas. LNG is primarily used for power generation the world over.

The physical steps in production and uses of LNG are:

- Gas production
- Liquefaction
- LNG shipping
- Receiving and regasification
- End use

The above mentioned steps are typically referred to as a "LNG Chain". Each element of the chain has to be individually viable to make the entire chain viable. While the first three are generally called upstream activities the others are the downstream activities.

The industry consists of entities, which sell LNG (called "seller") to entities, which buy LNG (called "buyer"), supported by service providers, vendors and financial intermediaries. A seller is often a consortium of several sponsors and is often owned by the nation where the gas reserves are located (host country). Generally, there is high involvement of the government of the host country in a LNG project. The ultimate buyer is typically a creditworthy electric/gas utility.

Proposed LNG terminals in India

As the pipeline proposals got into one trouble or the other, proposals for importing LNG gained ground. LNG import options have been pursued to meet the immediate needs for imported gas.

Name of the Company	Name of foreign collaboration	Location of proposed terminal	Capacity of terminal in million tonnes per annum (MMTPA)	Gas supply to	FIPB clearance	CCFI clearance	FDI
Enron International Inc.	Enron International Inc.	Dabhol (Maharashtra)	Initial 2 MMTPA expand to 5 MMTPA and further to 11 MMTPA	Maharashtra and other states	Yes, on 12.6.97 for holding company. 23.8.97 Project Clearance with investment from its affiliates	Yes, 19.9.97	USD 50 million
(British Gas) BG Plc.	(British Gas) BG Plc.	Pipavav (Gujarat)	Initial 2.5 MMTPA expand to 5 MMTPA	Gujarat	Yes, 23.8.97	Yes, 17.9.97	USD 140 million
Ispat Group of Industries	Ispat Energy Ltd.	Kakinada (Andhra Pradesh - A.P.)	Initial 2.5 MMTPA expansion unspecified	Andhra Pradesh	Yes, 18.10.97	Yes	USD 17[illegible] million
Reliance Industries Ltd.	GDR/ADR/ Private placement	Jamnagar and Hazira (Gujarat)	5 MMTPA at each terminal	Gujarat and other states	Yes, 29.11.97	Yes	Rs.115[illegible] crores
Royal Dutch Shell Group of companies	Royal Dutch Shell Group of companies	Hazira (Gujarat)	2.7 MMTPA initial. Expansion unspecified	Steel Ltd.	29.11.97	Yes	Rs.583 crore
Petronet LNG (ONGC, GAIL, IOC, BPCL, NTPC)	-	Dahej, Cochin	5 MMTPA at Dahej, 2.5MMTPA at Cochin	Gujarat and Kerala	--	--	-
CMS Energy/UNOCAL/GVK Tractabel	CMS Energy/UNOCAL	Kakinada (Andhra Pradesh)	--	Andhra Pradesh	Yes	--	-
Total/TEC	TOTAL	Trombay, Maharashtra	2.5 MMTPA	Maharashtra	Yes	--	-
TIDCO	-	Ennore	5 MMTPA	Tamil Nadu	--	--	-
Nagarjuna	Hardy Oil	Kakinada (A.P.)	1.2 MMTPA	Andhra Pradesh	September 1998	Yet to be given	-

Source. MoPNG

Map showing the locations of some important LNG projects

